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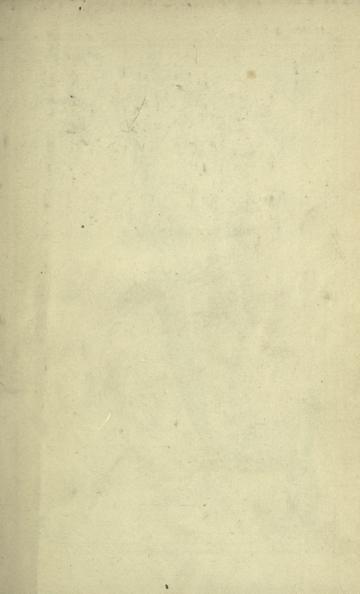
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LITTLE THINGS.



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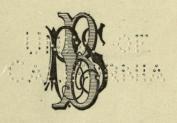
LITTLE LEIMOS.

GREAT WONDERS

IN

LITTLE THINGS.

BY REV. SIDNEY DYER, A.M.

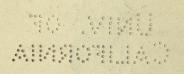


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PREFACE.

As the object in preparing this work was not to teach science, but to amuse and instruct children, the hard names and scientific classifications have been, as far as possible, omitted in the text. At the same time, care has been taken that the statements should be reliable descriptions of the different objects. The author has presented classes rather than individual species; but for the benefit of those who may desire to become acquainted with the terminology a list has been prepared to accompany each plate.

While aiming to bring minute objects as vividly as possible before the minds of the young, the author is aware that no description will give his youthful readers any just conception of microscopic revelations; hence he has provided carefully-prepared original and selected drawings of the forms of life described, and grouped them in

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classes, so as to give a vivid impression of the objects treated in the text, in most cases colored as near to life as possible.

In addition to his own long and careful studies, the writer acknowledges his large indebtedness to Ehrenberg, Gosse, Drs. Hogg and Griffith and Pritchard, from whom he has borrowed freely both statement and illustration.

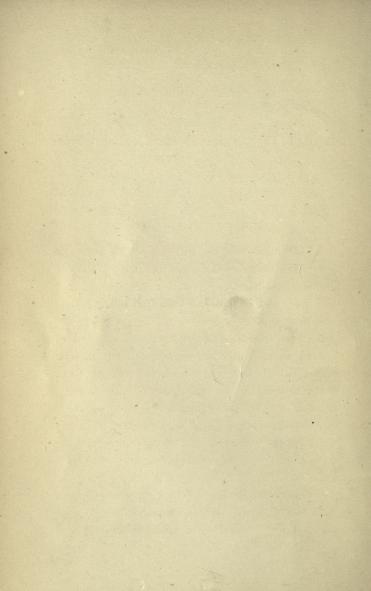
This work is an attempt to fill a wholly unoccupied niche in juvenile literature, and it has been the special aim to impress the young reader with the beautiful and profound moral lessons which Natural History, properly understood, always teaches, and for which microscopic studies furnish peculiarly impressive occasions.

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The Two Menageries.

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GREAT WONDERS IN LITTLE THINGS.

CHAPTER I.

THE TWO MENAGERIES.

"Now, isn't that too bad!" said Alf Green as the children came pouring out of the old brown school-house at Woodlawn, from which they had just been dismissed. "The great menagerie will be in town to-morrow with elephants, the hippopotamus, lions, tigers, monkeys, and all sorts of curious animals, and Mr. Willard will not grant us even a half holiday that we may go and see them. It is real mean in him, and I don't think we ought to stand it. I'm sure there can be no great harm in going to see a show of wild beasts. We don't often get the chance, and it is right down cruel to deprive us of such a rare opportunity to study natural history."

"But you forget," said George Snow, a sober and thoughtful lad who always respected the opinions and wishes of his teacher, "to state the reasons which

Mr. Willard gave to justify his refusal. You know he very clearly stated that he had no objections to the exhibition of natural curiosities, but could not approve of the circus connected with it, where men and women often appear very improperly dressed, who use vulgar and profane language, and whose evil influences will far more than counterbalance all the information that may be obtained. Besides this, you recollect, he promised that we should have a menagerie at the school which would contain more and rarer animals than would be found in the traveling show. Just remember, too, we're to have a jolly time in catching them all ourselves!"

"Now isn't that a likely story," responded Tim Allen. "I wonder where he will find his great curiosities in these parts? for I know every nook and corner around Woodlawn, and I haven't seen anything outside of our barnyard larger than a chipmonk or a musk-rat, and it is rather too short notice to fit out an expedition to Asia or Africa and hope to get back with our collection by to-morrow afternoon. He is only trying to pull the wool over our eyes, and I for one am not going to stand it. I guess my father will give me permission to go, if Mr. Willard won't."

"It does seem a strange promise," replied George Snow, "but Mr. Willard has never deceived us, and I confess I am more interested to learn how he will redeem his pledge than I am to attend the menagerie. I am quite sure he will have something particularly interesting to show us, and I shall not ask my father for an excuse that I may be absent without censure."

"That's just the way I feel," said Willie Hunt. "We all know that we have a glorious good teacher, who tries to do all he can to instruct and make us happy; and, for one, I'm not going to do anything that he disapproves of or manifest a want of respect. I'm sure we ought to return his kindness by at least respecting his wishes."

This, after a further interchange of opinion, seemed the general sentiment of the scholars as they separated for their homes. And as they scattered, there was such an increasing curiosity to find out Mr. Willard's secret as ensured a prompt and full attendance on the following day, without any very strong regrets at being deprived of the sightseeing at the menagerie and circus.

In every home that night there was much chatting and guessing as to what Mr. Willard could mean, nor could the maturer information of the parents throw much light on the subject, except, perhaps, in the case of good old Dr. Newton. In reply to the questions and chatter of his inquisitive little daughter Nettie, he quietly remarked that there were some things in this great world of wonders that could not be seen with common eyes, and it was more than likely that Mr. Willard possessed an uncommon pair, so wonderfully constructed that they could see strange things where there seemed to be nothing, and what was stranger still, he could lend them to others without impairing their wonderful powers.

Little Nettie's own eyes grew large with wonder as she exclaimed:

"Why, papa, I know that people sometimes wear artificial eyes, for I've seen old Mr. Brooks take one of his out and put it back again, but I didn't know that any one could see with such eyes."

"Neither can they, my pet," replied the doctor.

"But all eyes are not made alike, and perhaps your bright little peepers, which certainly are sharp enough for some purposes, and sometimes see a little too much, may find out many curious things by taking a look through Mr. Willard's wonderful optics. It is more than likely, when you have done so, that you will lose your relish for certain sweet things of which you are very fond."

Nettie was puzzled more than ever, but with all her teasing and fond kisses she could get no more satisfactory explanation of Mr. Willard's purpose, and had to wait until the next day should solve the mystery. It is but truth to say that it was a severe tax upon her curiosity and patience.

In this she was not alone, for many a young head, amid the slumbers of that intervening night, was filled with dreams wherein lions, tigers, monkeys, and other wild and strange beasts played a conspicuous part, with some nondescript creatures which are not found in Buffon or Goldsmith, and certainly did not meet 'their counterparts in the exhibition seen on the following day.

. When morning at last put to flight these creatures of the imagination, there was an unusual promptness in the youthful toilets in Woodlawn, and healthy appetites were quickly satisfied without much epicurean regard to the quality of the viands set before them.

The old school-house bell no sooner rung out the, for once, tardy hour of nine o'clock than there was a mutual rush to get the first sight of the collection of wonders which they supposed Mr. Willard would have to begin with. When all were at last seated in their usual places, it was not difficult to read those youthful countenances, where curiosity and disappointment were so strongly blended. Nothing out of the accustomed order met their gaze, save that on the desk of their teacher they noticed a number of small, open-mouthed glass jars, a few paper boxes

such as druggists use for putting up pills, and a small box in which these things seemed to fit.

As they sat looking at each other some could not restrain a quizzical expression, which plainly indicated their conviction that a practical joke had been played upon them. Others as plainly showed; by a nervous restlessness, their entire want of appreciation of such treatment on the part of their teacher. It seemed to be adding insult to a supposed wrong. Some were vexed and disappointed, and took no pains to conceal their feelings.

From a survey of those youthful faces one could not have failed in the conclusion that a large portion of the scholars had secretly resolved to play truant in the afternoon, in order to attend the contraband exhibition.

All this was plainly observed by the devoted teacher, whose countenance wore a calm but somewhat quizzical expression, indicating a quiet enjoyment of the groundless perplexity of his beloved pupils, yet evincing a consciousness of ability to remove all their unfavorable suspicions by affording them instruction and amusement which would more than compensate for the self-denial which he had called upon them to practice.

The school was opened in the usual manner, Mr. Willard reading before prayer the one hundred and

fourth Psalm. The children noticed that he read with unusual emphasis, especially when repeating the twenty-fourth and fifth verses:

"O Lord, how wonderful are thy works; in wisdom hast thou made them all; the earth is full of thy riches. So is this great and wide sea, wherein are things creeping innumerable, both small and great beasts."

After this interesting exercise was concluded, the teacher said:

"My dear pupils, I am much gratified at the confidence you have shown by your full and prompt attendance this morning, and I hope I shall so succeed in my efforts to instruct and please you that you will have no occasion to regret your cheerful acquiescence in my plans for spending the day, nor feel that you have lost any valuable instruction or real enjoyment by not witnessing the public exhibition which is to visit our town to-day. If, however, I shall unfortunately not meet your expectations, you must attribute it to a want of ability, and not to a want of proper regard for your highest good.

"As we shall have none of the usual recitations to-day, you may put your books carefully away. I suggest, however, that you provide yourselves with pencils and paper, that you may carefully make a note of what you may see or hear, closing up your

record by expressing your estimate of the manner in which you have spent your time, and the profit derived from the subjects which I may present. Let this record be made up as a true sketch of your feelings; and to all those who finally decide that they could have enjoyed themselves more rationally and pleasantly by attending the menagerie than by witnessing what I shall have to show, I promise a half holiday and twenty-five cents, the price charged for entering the show, to spend as they please.

"Now, permit me to say that objects become interesting to us both from their variety and the wonderful mechanism displayed in their organization. There is no more skill exhibited in the construction of an elephant or a lion than there is in that of the ox or the horse, and the only reason why they excite more curiosity than these familiar and useful creatures is because they are so seldom seen in our country, being natives of Asia and Africa, whence they are imported with great expense for the purpose of exhibition. In some parts of the world our common animals are as great a curiosity as are these noble beasts to us, and it is certainly a gratifying fact to know that ours are far the most useful.

"Most of you, if not all, have seen specimens of all the strange animals included in the collection which is to visit our town, and would, therefore, learn little that is strange or new. But there may be in this vast world of ours, so full of the riches of divine skill, creatures quite as wonderful in their construction and habits, and, indeed, much more so, which you have never seen, and of whose existence you have, perhaps, no knowledge.

"Because they are so much smaller will in nowise lessen our wonder, but rather increase it, as they exhibit the Creator's power and wisdom in a more marvelous degree. Man can imitate all large creatures by carved images or painted likenesses; he can construct models of all their organs, and place them in the body properly located—in short, do all but give the animal the breath of life. But when we find creatures so minute that our unaided natural senses utterly fail to discover even the fact of their existence, and when discovered by the aid of the most wonderfully constructed instruments we find it quite impossible for us to handle and dissect them, we can only say with the inspired and astonished Psalmist, 'Such knowledge is too wonderful for me.' With these marvelous forms of life we can do nothing: it is only with a magnified image that we learn something of the invisible reality.

"It is to such a world of nature that I seek to introduce you to-day, and if I mistake not, you will be wiser when night shall come, and I trust better

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also, for unless this shall be the result, your know-ledge will profit you little. The mere knowing is but a personal gratification: it is what that know-ledge leads us to do that is the great end of all just attainments:

"'Tis not what you know, but the good you may do,
That rounds out your manhood, full, earnest, and true."

"The works of God are sought out by all those who have pleasure therein. But unless each acquisition leads to a greater reverence and love for him whose wisdom and goodness created all these things, our knowledge but puffeth up, and is vain. For a man that is in honor, and understandeth not, is like the beasts that perish!"

Che Expedition.

PEDIFION

Title a be a mermission, Mr. Willar a came the children, and

se pay so set as said he, "requering sonal courage to the time huge happered this result tour, on the kingly long

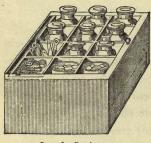
CHAPTER II.

THE EXPEDITION.

A FTER a brief intermission, Mr. Willard again called the attention of the children, and resumed his discourse.

"It may be an act," said he, "requiring more personal courage to capture the huge hippopotamus in his reedy lair, or beard the kingly lion in his native jungle, than we shall be called upon to exercise in making our collection to-day; but I feel quite sure that we can realize as much true pleasure in the pursuit of our treasures as do the Eastern Nimrods, and we shall have no distracting fears of the fatal results often attending their more daring expeditions after the fierce denizens of the Asiatic Nor shall we have to hunt so far and so long for our prey as to become overwearied, and thus lessen the pleasures of our excursion. In another respect we have a great advantage over hunters after larger game. Their outfit often costs a small fortune, for which they get little or no return, as they frequently come back more emptyhanded than they went. A few dollars is all the expense we shall incur in providing our full equipment.

"Our cages are not large nor very strong, as you at once perceive.



Jars for Specimens.

"Small and frail as they are, they will prove ample for all the purposes of our expedition, being abundantly capacious and secure for all the captures we shall make. Small as they are,

however, I shall be greatly disappointed if you do not return with a vastly larger collection of wonderful curiosities than can be found under the great canvas tent which I saw them pitching out yonder on the common as I came to the school-house this morning.

"In our hunting expedition the girls can share without the least fear of harm, or of doing anything unbecoming the proprieties of their sex. Indeed, I shall be much surprised if they do not return with quite as large an assortment of curiosities as the boys will obtain. To them I shall assign these little boxes as receptacles of what they may secure. To

you, boys, I will distribute these little bottles in the case now before me, and permit me to express the ardent hope that you will never use a bottle to any worse purpose. Many have found the bottle to contain something far more dangerous than the wild beast of the forest-something which at last 'biteth like a serpent and stingeth like an adder.' Most fatally does it fasten its poisonous fangs in the bosoms of those who thus dare to toy with it.

"Our searching will have to be made in various directions, in order to secure a sufficient variety of animals to make our exhibition interesting, and you can divide yourselves into parties according to your preferences, each different company taking one or more of these bottles and boxes. Small as they are, you will doubtless bring back in them a far greater number of wonderful creatures than you now have any conception of, yet your cages will not be overcrowded nor will you be burdened in bringing back your acquisitions.

"By a count which I have made, the show on the common will contain less than one hundred animals, including the beautiful horses, which form a large part of the attraction. My calculations will be very much at fault if you do not bring back in each one of these receptacles hundreds and thousands of most curious and wonderful creatures, although some of

you will return with apparently only a few drops of clear water.

"One thing further before I distribute these requisites of our expedition.

"If there is a boy or girl present who really does not wish heartily to join in our day's enjoyment, let such a one please hold up the hand, and leave of absence will be granted, as we want no unwilling members in our company." Mr. Willard paused for a few moments, but there were none who seemed disposed to avail themselves of this once-coveted privilege.

"I am very much gratified," said Mr. Willard, "to find that none wish to withdraw from our circle."

Taking up one of the bottles, he continued:

"I noticed last week, as I passed by Deacon Norton's pasture, that there was a small pond of water which has remained there under the influences of the warm sunshine ever since the last refreshing thunder shower. It has rested there on the rich sward, appearing bright and clear as when it first fell fresh and sparkling from the clouds. I especially want a bottle of that, and will assign to Alfred Green, and three or four others who may choose to accompany him, the duty of obtaining it. Do not let the commission be regarded as a small matter, for it is more than probable that you will bring to our collection

more trophies than any other party which may be sent out.

"Willie Hunt and party may search the old ditch running through Squire Walton's bog meadow, making their captures where the rushes and spatterdocks grow so thickly from its muddy bottom. It is a region full of life, and I have little doubt that many very curious specimens will be added to our collection.

"George Snow, you may fill your glass cage in the adjoining field, where there's a stagnant pond filled with water-lilies and long fronds of hornwort and Vallisneria, with some portions of its surface wearing a greenish covering. I will answer for the full complement of rare creatures which you will capture by the operation.

"Timothy Allen may visit the marl pits over the hills, where will be found deposits of two varieties of marl, distinct both in color and composition-one being a mass formed almost entirely of shells, many of which are of good size and of perfect shape, while the other is of a dark green shade, appearing as a sandy, friable substance, but being in reality the skeletons of an extinct race of tiny creatures, millions of which are found in every square inch of the deposit. It is owing to this fact that it has become a source of great wealth to the neighboring farmers,

bringing rich fertility to fields which would otherwise not pay for their culture.

"Another party of boys may secure some water from the clear spring brook behind the old stone meeting-house, taking it up where the thick watercresses grow, and though we may not find so many animals in the water which they will obtain, we shall obtain some very beautiful ones, with a multitude of objects of rare form and color."

The boxes were then distributed to the girls, who were sent to catch vagrant butterflies and millers with as many varieties of colors as possible, to bring thimbles full of Tripoli dust and rotten stone, chips of limestone or marble, grains of stale sugar, the dust of old figs, damaged flour, stale vinegar, and many other things which might add interest to the future examinations, until each scholar had some important commission to fulfill in the grand preparations for the coming entertainment.

This arrangement completed, the school was dismissed until two o'clock in the afternoon, when each party was to report the measure of success, and the grand results of the entire campaign were to be produced.

In the excited group which once more came pouring out of the old school-house door there was not one who entertained any lingering regrets about missing a visit to the exhibition on the common. They began to have an inkling of the nature of the treat which their teacher was preparing for them—a field of interest entirely new, and one which they felt it would be a rare opportunity to investigate.

When they scattered to fulfill their various commissions, there went forth a happy company of youthful searchers after the wonderful. So eager and earnest were they that the distant sound of the circus band approaching for the grand entree into the borough did not long delay many of their active feet, but away to the meadows and hills they rushed, happy in half a day's freedom, free to ramble among the beauties of nature, breathing the free air with elastic lungs that sent the fresh blush of the summer roses to their cheeks. Moreover, each one was inspired by a high mission that invested long familiar and neglected objects with an interest of inconceivable importance. The muddy ditch, hitherto so unsightly and so carefully avoided, the puddle of stagnant water, the green scum that had only suggested fever and ague, the imbedded lump of marl or chip of marble, now contained marvelous wonders and untold volumes of wisdom which they were soon to possess. Such chasing of feminine feet after butterflies and trapping of moths and millers, such rummaging into Biddy's scouring-box and pantry for

rotten stone and brown sugar, and such splashing into muddy ditches and slimy ponds were never before seen in Woodlawn.

The farm laborers in the neighborhood thought that the boys had broken out in a general rebellion against the authority of the master, and were preparing themselves with munitions to carry on the war, while the perplexed Biddies declared that the "girls had gone crazy entirely."

It was indeed wonderful how the juvenile population of Woodlawn had become excited by the wise manipulation of a skillful teacher. Instead of directly opposing authority, or the logic of moral relations, to draw his young charge from a hurtful indulgence, which would likely have provoked stubborn resolves of stealthy gratification, he had diverted their minds by presenting something that would feed the natural cravings for novelty. By superior attractions he was drawing them into wisdom's ways. The steps thus far taken showed how large a promise there was of a complete success. He is wiser who prevents the doing of an evil deed than he who wins to repentance after the offence has been committed.

The children not only went forth excited, but with their senses quickened. Especially was it true of their manner of observation. They had "sharp eyes" that forenoon, each one resolving to find out, if possible, what they were to carry back in their receptacles before they submitted their acquisitions to the teacher's inspection. Not a few of them did discover some wonderfully curious things, which they were quite positive were just what they were sent after, and were not a little elated at the supposed success. They found out many curious objects by such careful searching under leaves of water lilies and cresses, old mossy stones and logs, and slimy deposits, of which they resolved to make special report when called upon in the afternoon. Astonished by these unusual forms of life, they wondered how they could have remained so long undiscovered when they were so easily found. They were thus learning the lesson that there are many who, having eyes, yet see not, because they do not use them aright. Looking is not always seeing. There may be thousands of beautiful things all around us, yet we may remain quite unconscious of them, because we fail to exercise perception enough to recognize even their existence, much less appreciate their attractions. God has made the beautiful things of earth, and scattered his wondrous works all around us, that we may learn how

[&]quot;All matter quick, and bursting into birth;
Above, how high progressive life may go!
Around, how wide! how deep extend below!

30 GREAT WONDERS IN LITTLE THINGS.

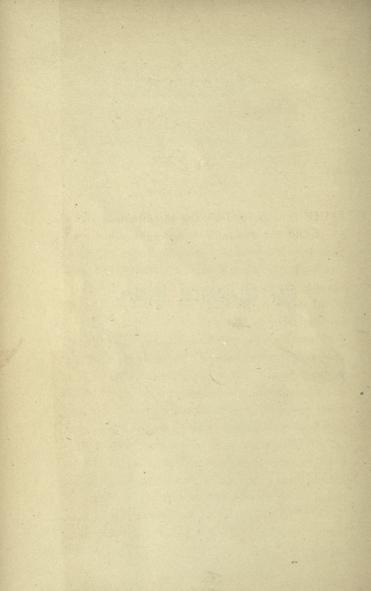
Beast, bird, fish, insect, what no eye can see, No glass can reach, from infinite to thee, From thee to nothing.

* * * *

All spread their charms, but charm not all alike :
On different senses different objects strike."

The Monderful Optics.

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CHAPTER III.

THE WONDERFUL OPTICS.

THE hour for commencing the afternoon session found the several companies assembled with their trophies, bottled, boxed, and encased, living and fossilized. Each youthful enthusiast had some exciting incident of the expedition to relate, or wonderful object to present, which he thought must be the very thing he had been sent to obtain.

Sidney Marvin, who had led the exploration to Lawrence's creek, back of the meeting-house, had captured several curious little creatures encased in oddly-constructed dwellings, out of which their heads were protruded when not alarmed. He produced one with some degree of triumph, saying:

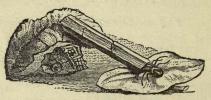
"Oh, Mr. Willard, I've got the funniest little creature here you ever saw! Just see him! He lives in a log house with a little stone glued to one end of it. I guess this is just what you sent me for."

"Well, Sidney," replied the teacher, "you have brought us a very curious addition to our collection,

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and one that I am very glad to have, although I did not think of him when I sent you out.

"It is a specimen of the caddice worm, which is gradually transformed into the well-known case fly, which you so often meet with around meadow brooks,



Cuddice Worm.

being in form much like the dragon fly, or 'devil's darning-needle,' as you boys are accustomed to call it, though of a much smaller size.

"They are amusing little fellows, those cads. Sometimes their home is a spherical case of three or four joints, as in the specimen before us, but more generally constructed by laying three sticks across each other in the form of a triangle, and then repeating the process until a sufficient number are added to complete the structure. This has a rough exterior, and serves as a kind of protection from its enemies, as an abattis does to a fort. Within, however, he is careful to adjust everything with the utmost smoothness, over which he puts a rich coat of plaster. These houses are sometimes constructed

with nice regard to beauty, being formed of alternate shades of color, put in fine contrast, from which many a one might receive a profitable lesson on taste.

"Another mark of the intelligence of this little creature is seen in the manner of securing itself from destruction by the rapid current of the stream where it makes its house. Being constructed of very light material, it would, if not prevented by some device, float in the current, and thus be dashed to pieces, or worn out by constant friction. How is this to be prevented, yet freedom of motion be secured? The little cad selects a small pebble, such as it can easily drag about with slight efforts, yet sufficient to anchor it to the bottom when these efforts cease. A nice matter of adjustment, you would say, requiring scales and measuring line; but our little friend hits the happy medium without the use of either. The instincts which God bestows on some of the most insignificant of his creatures often baffle our higher gift of reason, both in the use of means and in the achieved results.

"I have taken great interest in watching the habits of these little log-cabin builders, having early introduced them into my aquarium, where, above all, their ways can be observed. For some weeks all seemed to make progress in my little colony. One day, however, I found all the cases of my pets

empty and desolate, nor could they be found. They were not in the tank, nor had they passed into their flyhood, for in this case they would be found flying about the room, from which they had no opportunity to escape, but they were not there. It was a mystery that I could not solve. Not wishing to leave my collection without them, I at once procured some more, and put them into the aquarium just before sunset. Alas! when morning came there were my empty cad-houses. Not a living specimen remained, and worse than all, I then noticed for the first time that all of my faithful snails had also disappeared from their shells. Here was a calamity that must be looked after. A half a day spent around the ponds and brooks abundantly supplied the places of my lost treasures, but you may be sure I was interested in their subsequent progress, and sat down quietly to watch over their safety, and if danger assailed them to learn from what source it came. I had not to watch long, for hardly was the water quiet from their introduction, and they began to push out their heads to peep about in their new home, when a small eel not more than three inches long, which I had recently introduced into my collection, darted out from his concealment and seized one of my poor caddies by the head. Then there was a struggle: poor cad tried to withdraw into his citadel, and the hungry eel to pull him out. At a fair, square tug it was an even match, and after a few hard pulls the eel changed his mode of warfare. Throwing himself into a perpendicular position, he assumed a perfect state of rigidity, and began to whirl round with great velocity, thus putting the screw on the doomed cad, who began to yield more and more to the twist until so far out that he could make no more resistance, when he was devoured, and the eel made for the home of one of my busy snails. I had found out the bold robber of my treasures, and notwithstanding his graceful movements through the water, he was devoted to his native place, the millpond, to the great relief of my snails and caddice worms.

"But, Willie Hunt," said the teacher as he noticed this youth carefully nursing something in one of the bottles, "what have you got that is attracting so much of your attention?"

"Why, Mr. Willard, I've got one of the funniest little fishes here. Its back is all covered with sharp spines, and it changes its color so beautifully. But that's not the most curious thing. I found it in a nest, just between two stones, fixed almost like a little sparrow's nest, and there were lots of little ones there, too. I never knew that fishes ever made nests before."

"Well done, Willie! You have had your eyes about you, or you would never have found out so much about the little Stickleback, which is the name



of your fish. It is very common in creeks and ponds, but being so minute, very little is known of its existence or habits, except as an

inmate of a good aquarium, where he is ever admired as one of the most beautiful objects.

"The only objection urged against him is the impossibility of keeping him in a tank with other fish, making it necessary to provide him a separate apartment. Though so small, he is a brave and gallant little fellow, and will attack and destroy fish many times larger than himself. Passing suddenly under them, he drives his sharp spines into their vital parts—a thrust from which they try in vain to escape. I have had them often, but from this propensity I have had to banish them from my collection and keep them in a small globe by themselves.

"It is a curious fact that the stickleback builds a nest. Like the sparrow or wren, he gathers up his bit of weed or fibre of conferva, and takes it to some cleft of a rock or crack in an old log, until the nest is completed. Having done this, he tries to allure his mate into it. It is at this time that he puts on his splendid coat of mail, which changes anon to green, gold, purple, or silver, and often all these brilliant hues combined in one splendid suit of armor.

"To his mate and progeny he is most devoted and faithful. When the eggs are deposited in the nest which he has made, he takes the exclusive care of them, and continues so to do until they have matured and are able to look out for themselves.

"I have sometimes tried his bravery at this by poking a little stick near his well-guarded nest, when, with a vindictive spitefulness, he would fly at it and bite with great fury.

"Well," continued the teacher, "we have had two very interesting objects, neither of which did I think to have in my collection this afternoon, as they are not among the wonders which will properly constitute our exhibition. Perhaps there are some other parties who have been equally as successful in bringing back some interesting object. If so, it will afford me great pleasure to have them produced."

"Please, sir," responded George Snow, "among the thick spatter-docks, where the water was very still and warm, I found a very curious creature, with its head hanging down in the water, with a broad, feathery-like tail spread out on the surface, and I

have brought it, thinking perhaps it was what you wanted. Here it is in this jar."



Grub Chameleon Fly.

"I have no doubt, my boy, you have in that jar what I sent you after, but I hardly think you have found that out yet; nevertheless, let us see what you have discovered.

"Well, well, you have been fortunate in obtaining a specimen not easily found when carefully sought after. Your rare captive does not belong to the legitimate objects which will constitute our menagerie, nevertheless it will be no loss of time nor detraction from the interests of the exhibition to pause a few moments while we examine this strange and beautiful

creature, or, we might more properly say, beginning of a creature, for the object before us is the grub of the graceful *chameleon fly*. Its form, motion, and

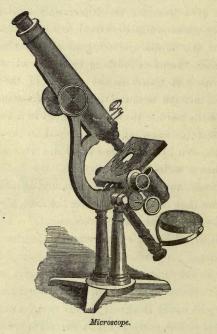
organs can be observed by the natural eye, though much better seen by using something to aid the sight—a process which you will much better understand when we have completed our series of examinations.

"I will not now detain you with any lengthy presentation of the process by which this interesting creature passes from its larval to its perfect state, but will merely call your attention to the splendid plume-like crown of feathers by means of which it floats when it comes to the surface of the water, which it always does tail foremost. As soon as it reaches the top the plume spreads out in a beautiful circular fan, somewhat funnel-shaped in the centre, from which all moisture is excluded. This feathery cone has a wonderful faculty, like the feathers of water-fowls, to repel all dampness, and it is through this cone that the insect breathes the fresh air necessary for its existence and development."

Had Mr. Willard's experiment ended here, most if not all of his gratified pupils would have felt fully satisfied that their half-day's excursion was far more delightful than would have been an equal length of time spent under the great canvas tent, jostling with a heated crowd, and subject to the offensive odor of caged animals. But their enjoyment had only just commenced.

42 GREAT WONDERS IN LITTLE THINGS.

During their delightful morning's roaming after objects of curiosity Mr. Willard had not been idle, as was apparent from the arrangements which the school-room exhibited. On a long table in front of the teacher's desk there stood six beautiful brass instruments, in shape like the following.



Beside these lay a number of glass slides, some of them having small cup-like cavities in the centre,

with two or three pairs of forceps and some other small instruments.

The various boxes and bottles, as they were received, were arranged on the table near the instruments, until there was a large collection grouped around the teacher, indicating that there would be no lack of objects for the afternoon's exhibition. The teacher was gratified at the lively interest manifested by his pupils, and felt that all the pleasure would not be found palpitating through their buoyant hearts. He was happy in striving to make others so, and felt as never before the importance of the teacher's office. He was not simply to impart to them what he knew—that was comparatively an easy task—but also to divert their minds from that which would be injurious.

When all the scholars had made their reports, and he had finished noticing the special objects to which some of them called his attention, he said:

"Children, I am exceedingly gratified at the manner in which you have entered into and carried out my suggestions for spending the remainder of this day, not only because it shows such a willingness to gratify me, but as it will, no doubt, furnish me with ample means for giving you pleasure and instruction."

Calling their attention to the instruments on the table, he proceeded to explain their uses.

"I shall not attempt," said he, "to give you a



Lenses of Microscope.

detailed description of these instruments, called Microscopes, as it would consume more time than we have to spare to make you understand fully their construction and uses. Besides. when you begin the study of Natural Philosophy, in the department of Optics, you will have a full explanation of their wonderful powers. Suffice it now to say that the microscope is constructed with glass lenses of different focal powers, so combined as to make an object appear many times larger than it really is. This diagram which I have drawn will give you a general idea of its construction.

"This is called a compound microscope. At the small end o, the object is placed, which is there magnified by one or more small lenses, and reflected on

the large lens at ff, which converges the ray of light in such a manner that a picture of the object is seen at b b, called the diaphragm, placed there to prevent the image from being seen at a a. This image is further magnified by the eye-piece at ee, as if it were an original object.

"Let us now illustrate the effect of this careful combination .

"Alfred Green is five feet high. Imagine this number multiplied by four hundred, and we should have a giant stretched out to the altitude of two thousand feet, rather taller than the one advertised to appear at the circus this afternoon. The top of the cupola on our school-house is fifty feet from the ground, and you think it rather a tall steeple. Now, if you could put Alfred under this instrument, he would appear nineteen hundred and fifty feet taller than our cupola. He would have to make a profound bow to enable him to pick the ball from the tallest steeple in the world, and Bunker Hill monument would only serve for a stool for him to sit on.

"But as we cannot put him under the glass and convert him into such a 'tall fellow,' let us take other objects upon which we can produce just such marvelous changes.

"In these vials and boxes, which you have filled from various sources, and where you can see only seemingly pure water, or a fine powder or grains of sand, there are doubtless millions on millions of animalcules and beautiful shells, which the unaided vision cannot detect, but placed under these instruments, they are magnified hundreds of times, so that we can see their forms and color, observe their motions and habits, and even distinguish many of their organs, tracing out their processes of digestion and wonderful manner of reproduction.

"By this wonderful glass we are made acquainted with a world so teeming with strange forms of life as to put calculation totally at defiance. We see them assuming such marvelous forms, sparkling in the most brilliant hues, multiplying with such incredible rapidity, and leaving such astounding results as to stagger and bewilder the senses. What does not appear to exist at all is found to exist everywhere, and that which seemingly is not is revealed as the foundation of nearly all the magnificent structures in physical nature.

"What a lesson does this teach us! The same relation which these minute forms of existence hold to the sublime whole which they serve to make up do these little acts and influences in our manners and life sustain to the character by which we are estimated among our fellow-men.

'For character growth

Day by day, and all things aid in its unfolding.'

"We must guard against the little foxes that

spoil the vines. We cannot, therefore, be too careful in searching out and correcting these little habits before they have become so multiplied and fixed as to give shape and tone to our manhood. White lies and little sins will aggregate into perjury and fraud, and are sure by-paths to the 'broad road that leadeth to destruction.'

"It is, indeed, an interesting sight to stand before a strong cage and mark the lithe and stately form of an African lion, or watch the huge elephant so deftly using his flexible proboscis, but I think you will experience greater astonishment when you come to inspect the contents of these bottles, where in one drop of water which you have taken from the familiar ditch you will behold untold millions of the strangest creatures, sporting, feeding, dying, and by this process laying the foundation of mountains and building up the everlasting hills.

"With this statement of the manner of our exhibition, I will now proceed to give a practical illustration of the wonderful powers of our optics."

A CONTRACTOR OF THE STATE OF TH Monads, Paramecium, etc.

PLATE I.

MONADS, PARAMECIUM, ETC.

FIGURES

1-15. Monads.

16-18. Paramecium.

19. Nassula elegans.

20. Acineta tuberosa.

21. Chilodon cucullulus.

22. Leucophrys striata.

23. Kerona postulata.

24, 25. Kerona mytilus.

26. Himantophorus charon.

27. Arcella.

28. Trachelomonas.

29. Cyphidium distortum.

30, 31. Chlamidodon.

32. Actinophrys viridis.

33. Actinophrys sol.

34. Podophrya fixa.

35. Glaucoma.

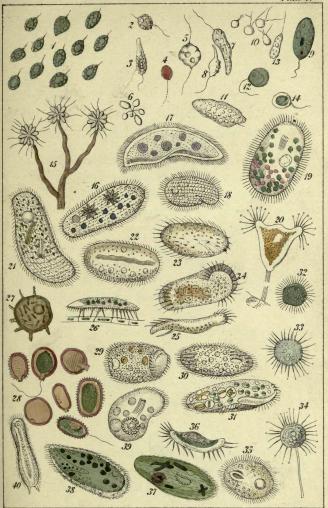
36. Euplotes.

37, 38. Bursaria vernalis.

39. Loxodes dentatus.

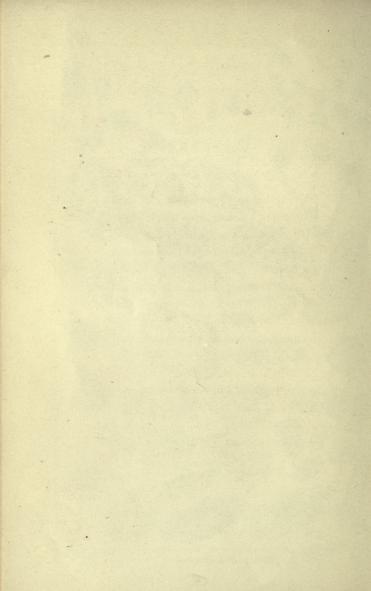
40. Chætonotus larus.

50



Monads, Paramecium &c.

Herline & Co. Lith Phil?



CHAPTER IV.

MONADS, PARAMECIUM, ETC.

"In exhibiting to you," Mr. Willard said, "the wonders existing in a single drop of water, I shall avoid as far as possible the use of the names adopted by the learned, as they are often very hard to pronounce, nor would you understand their significance. Some of you, it is hoped, will become so much interested in this branch of natural science that you will by and by acquire all these terms, and understand the reasons why they are applied to the objects which they designate.

"I will now arrange these instruments on the table, and place under them some of the objects which have been collected during your forenoon's ramble, and then each one will have an opportunity to observe the strange creatures which you have captured.

"I have not examined any of the collections you have made, and therefore know not how successful you have been, but judging from past experience, I feel very certain that we shall have variety enough

to engage us this afternoon, and several others also. Permit me here to say that I propose to devote one hour after the regular sessions each afternoon until we have gone through with the principal objects of interest revealed by our instruments; so we shall have our exhibition open long after the lions and tigers have left the town. The only charge of admission to our show will be good conduct and careful attention to study, and I wish it to be distinctly understood that I shall wholly exclude all those who are found deficient in these respects—a painful necessity which I fondly hope will not occur in a single instance during the interesting investigation which we are about to make.

"But now to our work. First let us see what Alfred Green has found in Deacon Norton's meadow. You see that the bottle appears to be filled with almost pure water, a slightly yellowish tint being just perceptible. One drop of this will be placed in the cavity of these little glass slides and adjusted under the instruments. Placed thus, you perceive that the water appears perfectly clear, shining like a dewdrop; not very promising, you may say, for my exhibition. But let us see whether it is so or not.

"Ah, boys, this is better than I expected! One of these drops contains inhabitants enough to outnumber by many thousands the large animals in all

the menageries the world contains. They are teeming with active life in many curious forms, the principal one being, as was expected, the various species of the monad. (Plate I., Figs. 1-15.)

"It is impossible to tell exactly how many of these little atoms there are in these drops of water, but that there are thousands upon thousands you can plainly see, yet there is sufficient space for the display of their constant activity. Small as they are, it is evident that there must be still smaller forms of life upon which they are preying; and it is most probable that the animals thus destroyed live by subsisting upon others yet farther removed in the diminishing scale, until we are confounded and lost in trying to follow out the connection to its last reduction—the most minute order of existence.

"Those who have given the most time and careful investigation to this department of natural science tell us that a single drop of water will often contain more millions of these little creatures than there are inhabitants on the globe, yet leaving them space for all the active purposes of their existence.

"It is almost impossible to conceive of animated creatures the twenty-four thousandth part of an inch in length possessing organs of motion, digestion, reproduction, and defence, yet such is the truth; and even more astounding, the scale of diminution has

been measured downward to more than double this number, or the fifty-thousandth of an inch, without reaching the end—the smallest measure of a living being.

"That we may have some conception of this marvel of creation, it has been estimated that a million of these creatures could find room for existence and display on a spot not larger than the period at the end of an ordinary sentence. The mind becomes bewildered under the conception of such a display of divine wisdom and power. It is awed into more reverence than when surveying the gigantic proportions of the elephant, or the majestic appearance of the lion. These we can weigh and measure, and easily comprehend the sum of their proportions; we can dissect their organs, form models of the exact magnitude of their bodies, and learn all the mechanism of their frames; but we cannot pick out, by individual selection, one of the thousands of atoms in these drops of water, much less analyze its parts with any degree of certainty. By resort to these wonderful instruments we become aware of their existence, and from a magnified image trace out something of their endowments. We are thus assured that God has created and given them a life as real as our own; that he has shaped their members with the same perfection of adaptation and workmanship, and given them a destiny to accomplish in their brief life which they are prompt and faithful in fulfilling.

'That change through all, and yet in all the same, Perfect in a hair as in the ethereal frame.'

"It is not simply to excite and astonish you by these wonders of creation that I open this minute world to your inspection, but to direct, if I can, your young hearts to the benignant Creator of all these things, who is just as minutely careful in 'searching our hearts and trying our ways' as he is in fashioning these mysterious forms of life. He who puts these things beyond the range of our natural vision, while yet scattering them all around us, will just as surely 'bring every secret thought into the light of his countenance.' However we may succeed in hiding our motives from the inspection of our fellowmen, or even concealing the remote springs from ourselves, God will faithfully scan them all, and weigh them in the balance of immutable justice. 'All things are naked and opened unto the eyes of him with whom we have to do!' In view of this solemn truth, let us all devoutly offer the earnest supplication of David: 'Search me, O God, and know my heart; try me, and know my thoughts, and see if there be any wicked way in me, and lead me in the way everlasting!'

"Monads are included in the general term Infusoria, so designated because they were first noticed in water where vegetable matter was decomposing, which led to the conclusion that this condition was necessary for their production—a deduction now known to be a mistake, as they are found abundantly in streams and ponds of clear water. An infusion of leaves or straw will, however, always produce them in greatest numbers; and it is not a little remarkable that, though we catch the pure rain water as it comes from the clouds, and take the fresh leaves before they have touched the ground, putting them into a clean jar, from which everything is kept out by being carefully covered, yet here these little creatures will swarm after a few days' exposure to light and heat.

"Monads are of various shapes and colors, as you notice, but mostly of an oval form, with one or more hairy filaments, by which they move through the water with great rapidity when so inclined. Their colors are red, brown, green, and various shades of yellow, this last being the most prevalent. Each species has some distinct characteristic by which it is designated, but it must serve our purpose at this time to give only a general view of the class, with a very few exceptions.

"The Social monads (Plate I., Fig. 1) are found in

great profusion. As they appear under our glasses, they are little yellowish oblong atoms, with a slight projection as their motive organ. When undisturbed, they manifest a disposition to gather in clusters around some bit of algæ, or if that is not present, they form a circle around the shallow edges of the drops, appearing sometimes like a golden ring. They are greedy feeders, and evidently carnivorous, as you are sure to see them cluster thickly around

the remains of any dead animalcule, as is strikingly illustrated in the drops under the glass I am now adjusting. Some poor an-



nelid has gone the way of all the living, and our little monads are making a rich banquet on his remains.

"Next to these, perhaps, in numbers, is the Monas lens. (Plate I., Fig. 10.) They have generally but one filament, and are nearly globular. They manifest less disposition for activity than our carnivorous little friends, but seem quite as social in their habits, often appearing in clusters so woven together as to seem one body.

"There is another form of this little creature which

we must not fail to particularly notice, the Anthophysa or tree monad. (Plate I., Fig. 15.) In our specimen it consists of three branches, on the top of each being a full cluster of little pinkish animals. These after a time, like ripened fruit, leave their native stem, and go shooting through the water to root and branch, bear fruit and die. Animals growing on trees is a wonder greater than any they have to exhibit in the big tent on the common.

"Some others of the monads are deserving of a particular description, but time will not admit, and we must pass to notice some of their habits.

"Monads multiply by the strange process of subdivision, that is, one animal breaks up into many another fact peculiar to our exhibition by which we outstrip our rivals. Animals break to pieces, yet live? you say. Yes, even so, as we shall find in many instances before we get through with our investigations. They divide and subdivide, while some also bud and branch.

"The race of monads also multiply in the more usual way of eggs. By these two processes each individual becomes the progenitor of millions every twenty-four hours. What an incredible number, then, must swarm in every pond and puddle of rainwater! We may well cease to wonder that such a process, going on for thousands of years, will, from

invisible atoms, build up mountains and heave up continents.

"From the disposition of monads to cluster together around some collection of alga, their variety of colors produces no small resemblance to a bouquet of flowers, whose leaves seem to scatter and fall as some disturbing cause sends the mass of life careering again through their watery home.

"Next to the monads for numbers and activity, you will notice a multitude of silvery-white and yellowish creatures darting through the water. They are much larger in size and curiously surrounded by hairy fringes, which are constantly in motion. These are Parameciums. (Plate I., Figs. 16-18.) They are generally of the shapes here represented, but often make their appearance in other and quite variable forms. I have taken a drop of water from a drain near my dwelling, in which there is a deposit of decaying leaves, where these little creatures were so numerous as to defy all calculation, and although the unaided eye could detect no individual of the species, they gave the whole drop a milky appearance, and, when dried up, leaving a whitish sediment at the bottom of the glass. When placed under the instrument, they were seen swarming in the drop, and darting here and there with ample room for the display of their impetuous activity.

The effect was quite dazzling, having much the appearance of the rapid revolutions of a wagon-wheel.

"You will notice that their motions are very eccentric, the general movement being spiral and wavy, but all at once you will notice some exuberant little fellow suddenly stop in his flying speed, and begin to revolve exactly in the same manner as do the pin-wheels you are so fond of burning on the Fourth of July. After enjoying his whirl for a time he will as suddenly resume his onward flight.

"He is a hardy denizen of our little world of water, standing the widest extremes of temperature. I have often found them abundant when all other forms of life were rendered dormant or destroyed by the cold. Nor is he at all fastidious; he is found living in water that has become very offensive from putridity, and from which all other animals have disappeared.

"The little starry ornaments on the back are very beautiful, generally having a bluish tint that brings them out very distinctly, Occasionally they are seen double, which is only the act of self-division, by which they multiply like the monads.

"Some varieties of this family are very beautiful, as the *Nassulæ elegans* (Plate I., Fig. 19), marked with bright green and red spots and elegantly-fringed border. Nestled among the green conferva,

its usual place of hiding, it occasionally darts suddenly out, whirls spasmodically round, and then retreats again to its cover.

"The Chilodon (Plate I., Fig. 21) is a fitting companion to the last named. It has not its brilliant colors, but surpasses it in grace of form, with the addition of a bar of golden yellow obliquely drawn across its body.

"The Acineta tuberosa (Plate I., Fig. 20) belongs to another family, but is one of the most graceful objects presented to the eye whenever it comes under the glass, which, unfortunately, is not often—a beautiful, tufted, golden-hearted, triangular creature.

"But we have too many wonders under our glass to particularize them all, nor is it necessary, as you will recognize the others when you see them hereafter, if you are only careful in observing. Two or three, however, must not be passed by thus lightly.

"The 'Boat animalcule' (Euplotes, Plate I., Figs. 26, 30, 31 and 36) is quite common in some of its many forms, and is always distinguished by its peculiar manner of walking or swimming with its hairy appendages. When walking, it does so with a jerky motion, with sudden reversals of position; at other times it stands with its antennæ constantly in a state of vibration, as though warding off all that may ap-

proach to rob it of its captured monads or other victims to its rapacity.

"That little collection of red and green objects is made up of different forms of the *Trachelomonas* (Plate I., Fig. 28), a distant connection of the monad family. They are found quite plentifully in all bog meadows, where they sometimes give a reddish tinge to the shallow water.

"In these specimens we have also the Sun animal-cule, which you will at once recognize, and two forms of the Bursaria, those egg-shaped, green objects at the bottom of the collection.

"You wonder that so many new and strange things can exist in a single drop of water, and it is astonishing, but we are just on the borders of this enchanted world, with its rarest inhabitants yet unseen, and that we may not be delayed too long from forming their acquaintance, we must remove the contents of our slides, although by so doing we shall destroy more lives than was done during all the slaughter of the recent war. The facts with which you have just been made acquainted will prepare you to understand the grim witticism of a returned veteran, who was somewhat acquainted with the uses and revelations of the microscope. His station was for some time in the swamps of the South, and he said that 'he had destroyed more lives by a single

swallow of water than war had taken in a century.'
His statement was no doubt true.

"While I shall change the objects under our glasses, you can take a breathing-spell and have an interchange of thoughts."

Potifers.

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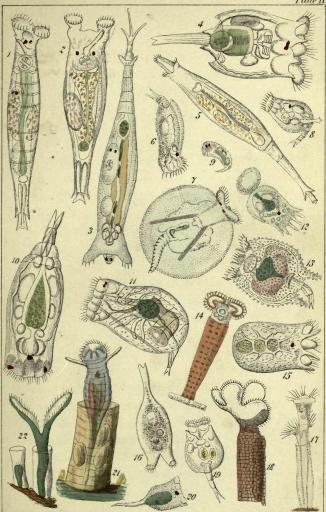
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PLATE II.

ROTIFERS.

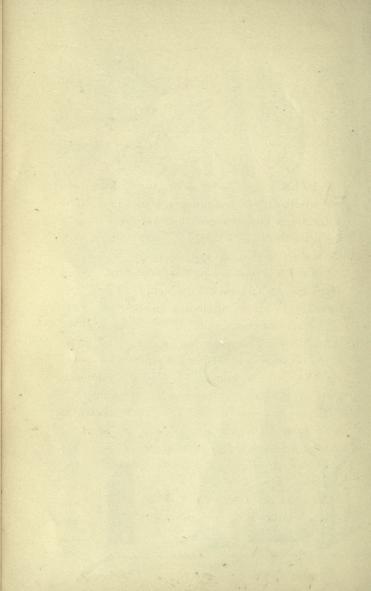
FIGURES

- 1. Rotifer Vulgaris.
 - 2. Philodina erythrophthalma.
 - 3. Actinaurus Nepturinus.
 - 4. Brachionus amphiceros.
 - 5. Callidina elegans.
 - 6. Salpina mucronata.
- 7. Pterodina patina.
- 8. Lepadella Ovalis.
- 9. Rattulus lunaris.
- 10. Eosphora digitata.
- 11. Diglena lacustris.
- 12,15. Anuræa.
 - 13. Noteus quadricornus.
 - 14. Limnias ceratophylli.
 - 16. Hydrias cornigera.
 - 17. Vaginicola crystallina.
 - 18. Melicerta ringens.
 - 19. Lepadella emarginata.
 - 20. Microcodon clavus.
 - 21. Æcistes longicornis.22. Limnis, or Snakehead.



Rotifers

Herline & Co. Lith Phil &



CHAPTER V.

ROTIFERS.

A FTER a brief intermission, during which Mr. Willard had readjusted his instruments and the children interchanged their pent-up thoughts, the little bell brought them once more to order, when the teacher resumed his exhibition:

"We will now see what remarkable things Willie Hunt has brought back from Squire Walton's pasture. Among them we shall be likely to find many of the same little creatures we have already been examining with so much interest, but I also expect to meet with one particular class which we have not yet observed—an animal of a higher organization than any we have yet examined. It belongs to a family having many branches, each one exhibiting some remarkable peculiarity, making it one of the most interesting studies to the microscopist. The individual which gives it the class name of Rotifer is called the Wheel animalcule. (Plate II., Fig. 1.) It takes its name from having the appearance of two wheels rotating at its head, called cilia, derived from

a Latin word which means eyelash. It is a strange appendage, possessed by most animalcules in some form, which we have already noticed in many of the animals examined, and of which I have not taken particular notice, preferring to leave it until we had under consideration the individual of which it is the peculiar characteristic. When you carefully observe this beautiful adjustment in the Wheel animalcule, you will see the appropriateness of the name and admire the perfection and grace of its motions.

"But while we are talking our little friend, I trust, is waiting for our recognition and admiration.

"Beautiful, beautiful! here they are in great



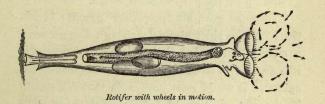
W. A. drawn up.

numbers and perfection. Some are drawn up almost into a ball, standing nearly or quite perpendicular, and looking not a little like an Esquimaux wrapped in his fur jacket. On one side is seen the form of a young rotifer, with his crooked neck and two little eye spots, and on the other the egg, not so far advanced.

"Here is another, stretched to his utmost length, probing about in all directions, as if



searching for prey. There is no appearance now of the beautiful wheels, but in place of them there is thrust out a small head with a dart-like projection. Notice, also, that there is a flexible horn, or feeler, just back of the jaws, but placed on the side of the head instead of exactly on the top. While thus stretched out it adheres to the bottom of the glass or some frond of algæ with its fringed suction tail. But see, suddenly the head is drawn in, and there are pushed out far in its advance those wonderful



wheels. What a change! Can this be our little Esquimaux ball, or slender, leech-like worm? Even so. Nothing like this among all the rare things in

the show on the common!

"Though the wheels of the animal are in motion, you see it does not move from its position, because it still holds on by the process already described. The effect is precisely like that of a steamboat tied to the dock with its wheels in motion, as is often seen in the ferry slips in winter in order to clear them from

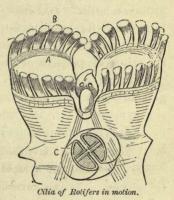
ice. Our little friend, however, has quite a different object: he is not clearing out, but drawing in, for you can notice the streams of monads and other minute things which enter within the vortex made by the revolution of the wheels.

"It is not likely that he will remain long in this position. Watch him, and you will notice that after a brief period he suddenly jerks backward, at the same time retracting his wheels, and the prey he has captured passes downward to the jaws, where it is ground up for the purpose of digestion.

"There he goes, his 'propellers' grandly in motion! Notice particularly the cilia; it does not seem a mere vibration, but a rapid circular movement, like a wheel on its axis, reversible at the will of the animal. It would seem impossible that this should be the case, as it would indicate that the wheel is entirely detached from the animal. Some have supposed that the movement is produced by a spiral adjustment similar to that of the Forticella-which we shall have under notice before we are done-only more extensive. By others it is believed to be electrical, or that the effect is the same as that produced by the wind passing over a field of grain, wave following wave so continuously that we are unable to mark the place of succession. With a very high magnifying power, we perhaps get at something near

a correct solution of this beautiful motion. The base of the cilia, a, remains stationary, while the point forms a circle, b. Take a stick and light one end of it, and then whirl it around, and you will have a

complete circle of light, while there will be no revolution of the hand. which is the pivot of the motion. This is probably the correct solution. But be this as it may. the beautiful adaptation and graceful motion of this living



'nature's propeller' may well excite our wonder and admiration.

"Unlike its huge ocean compeer, the rotifer carries his wheels in the bow instead of the stern. With the broad funnel-shaped front which is thus presented, it would seem that the movement would be backward instead of forward, yet the rapidity and ease of the creature's advance show a most perfect adjustment and adaptation of motive power. That engineer will outstrip Fulton and Ericsson who can find out the secret and apply it to practical purposes.

If the wheels are detached from the animal, how is the motive power applied? and if cilia with a fixed base, how can their circular motion produce an advance? A stick whirling around in the hand finds no resistance that would draw the hand forward. We have the living model before us, but where is the skillful observer who will search out the secret and apply it to the purposes of human industry?

"You notice that there are two wheels, revolving generally outwardly, producing two rapid currents setting toward the mouth, into which they carry the food, while the little creature is propelled onward in his voyage—quite an advantage when he is in a hurry, as he does not have to 'stop twenty minutes for dinner.'

"It is worthy of notice that the sperm whale secures his food much in the same way. It lives on a peculiar animalcule, so numerous as to discolor hundreds of miles of the ocean's surface, which it collects by the hairy appendages filling the roof of the mouth. It rushes through the water with open jaws, until this hairy sieve is coated with billions on billions of its dainty prey, which are then swallowed and the process repeated. The whalebone of commerce is this food gatherer, taken from the whale's mouth, the hairy ends removed, and then split up as we buy it. This is the precise manner in which the

wheel animalcule gets his nourishment. The whale is the larger animal, but our little rotifer is the greater curiosity.

"Water seems to be the native element of these living machines, though they are often found in damp earth, cells of moss, and even in the untidy hair brush of the toilet. They are very tenacious of life, continuing to live under conditions which would necessarily seem fatal. Let them be dried by exposure to the heat of summer, and so remain even for years, and a little water will restore them to life and activity. They almost seem to have a charmed life until they have served the purpose of reproduction.

"They appear to take special delight in the bright rays of the sun, and are always found thicker at the top of the jar in which they are placed, often sinking suddenly to the bottom when the light is withdrawn.

"This form of the rotifer is exceedingly common, and is found in every old ditch and pond of stagnant water, from which circumstance it has the appellation of Rotifer vulgaris, although he is anything but a vulgar fellow, as he stands at the head of a numerous race. Most nearly allied to him are the Philodina, Actinurus, and Callidina. (Plate II., Figs. 2, 3 and 5.) Their forms and habits are so near alike

we need not delay to make more special examination.

"The Rotifer propagates both by eggs and by bringing forth its young alive—facts which can be learned only by a long and patient investigation, conditions which put it out of our power to verify.

"Ehrenberg, a distinguished German naturalist, declares that a single rotifer will multiply into more than sixteen millions in twelve days. At this rate, in one month it would equal the entire population of the United States, and as each animal becomes a parent in a few hours, in this brief period a single individual has carried the statistics of his race altogether beyond human calculation. As this process has been going on for thousands of years, it has enabled this minute creature to make his mark among the other builders-up of earth's gigantic structures.

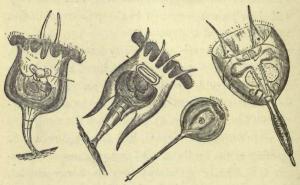
"Most of the species have strong jaws and teeth (see cut illustrating motion of cilia, page 7), crushing their food by a hammer-like action, with several capacious stomachs for its digestion, to satisfy which they consume enormous quantities as compared with their own magnitude.

"The little red spots seen on the head are supposed to be eyes, of which there is sometimes a double complement. These fiery red orbs must have a terrible aspect to some of their tiny victims.

"The next most remarkable member of the rotifer family is the Brachionus (Plate II., Figs. 4, 12, 13 and 15), which you have noticed darting and tumbling here and there in these drops of water, shaped like cups, bells, balls, and bouquets. They are a spine-bearing animalcule, some of them being encased in a hard, shell-like covering, and are among the most perfect and curious of all the world of animalcules. They are symmetrical in structure, and of ceaseless and eccentric activity. They are the acrobats of our menagerie, and some rare feats they will show us, not surpassed in the public exhibition by the practiced athlete.

"In some, the case is beautifully dotted and striped, with collapsed edges (Fig. 15), fringed around with cilia, beyond which project two horns. Here is one, and as it adheres to the plate by its slender retractile foot stalk (Fig. 4), it has much the semblance of a beautiful variegated bell-shaped flower just opening to the sunlight. At any appearance of danger it suddenly withdraws into its horny citadel, through the semi-transparent sides of which much of its internal organization can be observed. This is quite complex, and takes the hue of its principal food, being green, brown, or red by turns. We can take advantage of this, and by using a little carmine, indigo, or other coloring matter, give a new beauty as well as more easily notice the process of diges-

"The Brachionus seems capable of transforming itself into marvelously curious shapes, so that we are not always sure that we have a specimen under our glass until we have observed it for some time, and he will be sure to show his colors. This fact, with the large number of members included in the family, gives us some rare pictures to gaze upon, some of which are now before our eyes.



Forms of the Brachionus.

"Their movements are marvels of gymnastic feats. Swimming, crawling, throwing back and forward summersaults, at the whim of the creatures, and being of different hues and shades, they give a new and lively aspect to our minute world.

"Its chief food seems to be the monads and other smaller fry, which it gobbles up with great avidity and grinds between its hammer-like jaw, which you can see working so actively just below the revolving cilia.

"There are many other members of the great family of rotifers which deserve mention, as Eosphora and Diglena (Plate II., Figs. 10, 11), but we must pass them by and pay some attention to the little hermit Vaginicola (Plate II., Fig. 17), dwelling alone in a transparent home, from which he timidly comes forth as necessity may require. Sometimes there appears to be two animals, one growing out of the other, in shape very much like two morning-glories stuck one within the other, as is often done by the girls. The mouth is surrounded by the usual cilia, which is always in rapid motion when the animal protrudes from its shell.

"The Melicerta (Plate II., Fig. 18) also dwells in a tubular home, but it is quite opaque, and if what is hidden is half as hideous as that which is revealed, we should be grateful for the concealment, for such a horrid mouth fortunately is not often seen. Look at those four great lobes of whirling cilia which he pushes out so furiously, and mark how the stream of devoted monads goes rushing into his dark maw, and you will call him ugly and cruel.

"Not thus will you judge the graceful *Pterodina* (Plate II., Fig. 7). His home is a large circular shell, pale in color or quite transparent, with some very beautiful markings. He has a long prehensile tail, which he uses with great dexterity, and the double ciliated mouth of the head of the family.

"The *Œcistes* (Plate II., Fig. 21) is also a dweller in a cell, which is beautifully, though sometimes faintly, marked. He has a ciliated mouth, flanked by long horns. The three oval bodies seen through the case are the eggs, which are expelled after maturity.

"We shall only mention two other members of this interesting class, the Limnias (Plate II., Figs. 14 and 22). We have two varieties before us, the Ceratophylli, dwelling in a long, yellow, spotted case, with two lobes of cilia projecting, and rather attractive. But the other, though of a beautiful green color, in fine contrast with the glassy clearness of the cell from which it protrudes, is a snaky monster, with his huge mouth filled with seemingly sharp fangs, and wide open ready to devour whatever comes within their sweep. From his appearance under our instrument, we should almost fear to put our finger within reach of his jaws. We will let him pass, and with him take our leave, for the present, of the rotifer family.

"At this stage of our examination we will pause, although we have barely commenced our investigation of the collection which you obtained this forenoon, leaving abundant materials for future hours of enjoyment, to which I fondly hope every beloved pupil in my school will be entitled to free admission on the terms already stated.

"One thing more, and then I shall dismiss you for the day. All those who are dissatisfied because I refused you a half holiday to attend the show of wild beasts will hold up their hands and receive their twenty-five cents, with permission to be absent on to-morrow forenoon. What, not one? Now let all those who are fully satisfied with the entertainment which I have given in the place of it show . their hands."

In response to this request all hands went up with alacrity.

Mr. Willard contemplated the scene before him with an evident glow of satisfaction, and then, with much emotion, said:

"Children, I most cordially thank you. This evidence that I have succeeded in my efforts to furnish you with an innocent gratification causes me great happiness. But my intention was not alone to amuse you, although to do that will always give me pleasure. I have had a higher motive. It has

been my chief aim to convey wholesome lessons of intelligence and moral instruction—to give you, if I could, higher and juster conceptions of the divine power and goodness—in which intention I trust I have also succeeded, and this makes our pleasure mutual. This will beget a more entire confidence between us, so that hereafter you will the more readily yield to any suggestions which I may deem proper to make from time to time, being thus assured that I will deny you no privilege or enjoyment that is pure and healthful. Your happiness and well-being will always be my chief aim."

As Mr. Willard was about to dismiss the school, Alf Green arose, and, with much emotion, said:

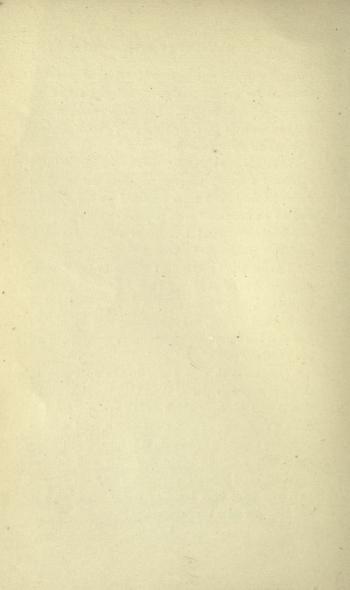
"Dear teacher, I can't leave the school-house to-day without making a confession. When you denied our request yesterday I felt angry and disappointed, and said so to my school-fellows; and now I can't be happy without confessing my fault and asking forgiveness before the whole school. You have not only given us amusement and instruction, which has filled us with wonder, but afforded me, and I believe all the scholars, a day of real pleasure, greater, I'm sure, than I should have had at the circus. Hereafter, dear teacher, you need use no other means to keep me from any place of amusement than to tell me that you have something to show me. In this, I'm

sure, all my school-fellows will agree, if you will allow me for once to take your place and ask an expression of their feelings. Let all the scholars who feel as I do hold up their hands. You see, teacher, they are all up once more!"

While Alf was speaking, the face of Mr. Willard exhibited a strong effort to suppress the emotions which he felt. The tears trembled on his eyelids, and he had to pause some moments before he could sufficiently command himself to reply. He then said, with a thickened utterance:

"I do not know who is the happiest to-day, teacher or pupils, but of one thing I am certain—we all are happy because we have tried to do right and follow the ways of wisdom, and in so doing we shall always find that her 'ways are ways of pleasantness, and all her paths are peace.'

"The best wish that I can bestow upon you is, that you may ever pursue them with the same cheerfulness and pleasure which have characterized this day's experience. Open alike to all, and having such rich treasures to bestow, it is surprising that so many turn away to follow the giddy and ruinous paths of mere sensual pleasure. May the blessed path you have been treading to-day grow brighter and brighter unto the perfect day!"



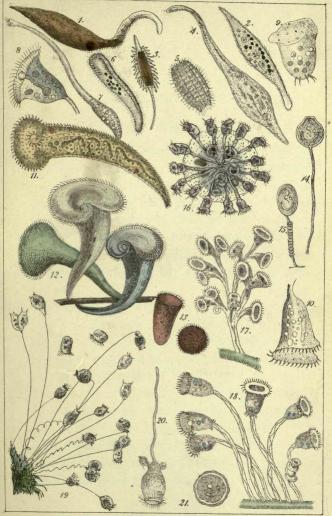
Porticella.

PLATE III.

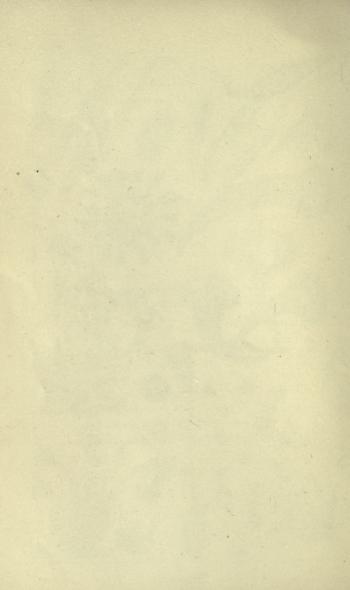
VORTICELLA.

FIGURES

- 1, 2. Amphileptus.
 - 3. Amphileptus papellosus.
 - 4. Dileptus.
 - 5. Coleps hirtus.
 - 6. Kondylostoma patens.
 - 7. Trachelocerca viridis.
- 8-10. Free Vorticella.
- 11-13. Stentors.
- 14, 15. Vorticella encysted.
 - 16. Conochilus Vorticella.
 - 17. Carchesium Vorticella.
 - 18. Convallaria Vorticella.
 - 19. Microstoma.
 - 20. Full-grown bud of Microstoma.
 - 21. Full-grown bud of Microstoma, stockless.



Vorticella &c.



CHAPTER VI.

THE VORTICELLA.

A HAPPY and wondering throng of children went that evening from the Woodlawn school-house, giving scarcely a thought to the perambulating exhibition from which their attention had been so skillfully withdrawn. Nor did their happiness cease with the entertainment at the school-house, but continued with almost unabated interest as they described the wonders they had seen to their gratified parents.

Little Nettie Newton now fully understood how people could see through glass eyes, and continued to talk about the wonderful things she had seen until her father suggested that perhaps her tongue had multiplied as did some of Mr. Willard's animalcules. There were many suspicious peerings into tumblers of water before the usually welcome beverage was swallowed, while some declared they would never drink another drop—a resolution which was forgotten on the following morning, or disregarded under the pressure of returning appetite.

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With many of the girls there was a careful cleansing of hair brushes, which even then were used with a kind of shudder, as though they could feel some lively rotifer twisting their silken locks in his wheels as he tried to navigate amid their luxuriance.

To many it almost seemed like a dream, so strange were the objects which they had seen of which they had previously no knowledge. Here they had seen them with their own eyes, but they could not fully resist the impression that in some way Mr. Willard had practiced upon them some sleight-of-hand: so strong was this conviction that it required the positive confirmation of their parents, in some cases, to remove it entirely.

The promised repetition of these magical revelations for an hour each day was sufficient to secure a prompt attendance and an increased attention to deportment and study, that their right to admission might not be forfeited—a contingency which occurred but in one or two instances during the whole course of the subsequent investigations.

According to promise, at the close of the next afternoon's session Mr. Willard arranged his instruments as before, and said:

"Dear children, we will now resume our explorations into the mysterious life existing in a drop of water, and I shall not be surprised if you are quite as much interested in the rare animals which will be on exhibition as you were yesterday, though the novelty will not be so striking as it was when you were first introduced to its strange inhabitants. I have some splendid little fellows for your examination this afternoon; in fact, they are considered by many as the most attractive of all the animalcules vet discovered. But of this you shall be your own judges.

"The Vorticella, or Bell animalcules (Plate III., Figs. 17, 18 and 19), are very abundant in all ponds and ditches where there are decaying weeds or grass, or other vegetable accumulations. They are often found also in many utensils used for holding water, or that remain for any length of time in a damp state. Thus the scraping of a wooden bucket in which water has stood will generally show them in great abundance and perfection adhering to the woody fibres which will be detached. They will breed in damp combs, hair brushes, bathing sponges, and other toilet articles which are not cleansed and dried with great care. Although not very horrid creatures, yet this fact should lead to great carefulness in all matters of cleanliness of person and those articles used in the process of cleansing it.

"The Bell animalcules may be regarded as equal in interest to anything revealed in the largest and highest class of animals. I think when you have seen them you will agree that nothing advertised as forming a part of the collection now in our town surpasses these minute creatures in beauty of form, nicety of mechanical arrangement, or variety and grace of motion, combining, as they do, the activity and elegance of the rarest animal life with the beauty and delicacy of the flowers.

"They have the cilia of the class last under consideration, although quite differently adjusted. But their marked peculiarity, and that which gives them a class name, is an attachment like a long, flexible, thread-like tube, by which they are generally found adhering to fronds of algæ or other permanent objects. It appears like a fine India-rubber thread, capable of an indefinite stretching, hollow through its entire length, and contracting instantaneously at the will of the governing head, taking a beautiful spiral form when thus drawn up.

"Dr. Hogg, of England, in his large work on the 'Microscope and its Uses,' thus speaks of this beauful denizen of the water drops:

""The Vorticella is not wholly condemned to pass a sort of vegetable life, rooted, as it were, to a single spot by its slender stalk; its Creator has foreseen the probable arrival of a period in its existence when the power of locomotion would become necessary, and this contingency is provided for in a manner calculated to excite our highest admiration. At the lower extremity of the body of the animal, at the point of junction with the stalk, a new fringe of cilia is developed, and when this is fully formed the Vorticella quits its stalk and casts itself freely upon the world of waters. (Plate III., Figs. 8, 9 and 10.) The development of this locomotive fringe of cilia, and the subsequent power of swimming by the Vorticella, are generally connected with the propagation of the species, which in this and some other of the allied genera presents a series of most complicated and curious phenomena.

"'This mode of reproduction is called gemmation. It consists of the production of a sort of bud (Plate III., Figs. 14 and 15) which generally acquires the form and structure of the perfect animal. In the Vorticella these buds, when mature, quit the parent stem after developing a circlet of cilia at the lower extremity, and fix themselves in a new habitation in exactly the same manner as the individuals produced by the division of the bell.

"'At an earlier or later period of their existence, the Vorticella withdraw the disc surrounded by cilia which forms the anterior portion of their bodies, and contracting themselves into a ball, secrete a gelatinous covering which gradually solidifies and forms a

sort of capsule, within which the animal is completely enclosed. By this process the little animal is said to become encysted, and at this point of its history it is seen to be more complicated. Sometimes its further progress commences by the breaking up of the nucleus into a number of minute oval discs which swim about in the thin gelatinous mass into which the substance of the parent has been dissolved. (Plate III., Fig. 21.) The body of the animal enclosed within the cyst now becomes apparently divided into separate little sacs, or bags, some of which acquire a considerable increase of size, and at length break through the walls of the cyst. After a time one of these projections of the internal substance bursts at the apex, and through the opening thus formed the gelatinous contents of the cyst, the enclosed embryos, are suddenly shot out into the water, there to become diffused and give rise to new generations.

"'But the final object of this singular metamorphosis still remains to be described. The nucleus, which at the change of the encysted animalcule was distinctly observable, becomes entirely and altogether converted into an active Vorticella, acquiring an ovate form, with a circle of cilia round its narrow extremity, and presenting at the opposite end a distinct mouth. Within this young animal, while still

enclosed in the body of the parent, we see a distinct nucleus and the usual contractile space of the fullgrown creature.'

"The process here described you can observe in the water drops under examination, although we have not sufficient time to delay and carefully verify the wonderful facts. We can see enough, however, in one of the specimens under our glasses, to give us a beautiful confirmation. Notice that splendid cluster of the Microstoma. (Plate III., Fig. 19.) You observe that every animal is attached to a separate foot-stalk of very great length, stretching out in all directions, and springing back with a graceful spiral motion. There is just perceptible in the little bellshaped head a bluish purple tinge, giving the animal a striking resemblance to a morning-glory trembling in the breeze, with here and there one breaking loose from its parent stem and whirling away as if exulting to be free from parental restraint. Some are double headed-made so by the forming of the bud which is to develop into the new generation. You can see the cilia putting out at the anterior end of the bell.

"Scattered through the water are numbers of these bud-like cysts, working like the soap-bubbles which you often blow from the bowl of a pipe, and, like the broken bubble, flying apart into the numerous germs of a new life. We can, when looking at wonders like these, say with Solomon: 'The eye is not satisfied with seeing, nor the ear with hearing.' We look and look again, and wonder if it is a dream or reality that we see. We are truly beholding something stranger than the

'Stuff that dreams are made of,'

yet as real as the everlasting hills—a delicate picture of Nature's painting, refining by its lessons of beauty in forms and adaptation, of mutual dependence and reciprocity.

"The Carchesium (Fig. 17) is of the same family as the last, but is noticeable from the fact that the clustered animals are all growing upon one main foot-stalk, from which they branch out in all directions—a living althea bush, which it will more nearly resemble in the pale, pinkish color of the flowers when we have put a little carmine into the water. There! is not that a beautiful living flower? The same graceful effect is seen in that splendid cluster of Convallaria (Fig. 18) near by. In this animal is seen the same individuality as in the first examined; each one grows on a separate stalk, and being larger in size, the process of propagating can be seen with more distinctness, and also the tubular formation of the thread-like attachment, with its spiral shape when the animal springs back.

"It is very interesting to watch the eccentric movements of the free Vorticellæ. They seem to exult in their deliverance from restraint; hence they part from the stem, where they have had their growth, with a violent jerk, and spring away with a flying speed. Here they go, over and over, like a gymnast turning summersaults, now stopping to revolve in an eccentric orbit or spinning like a top; now zigzag or with an up-and-down motion. Occasionally one will stop, and turning the mouth or the bell dewnward, will remain motionless, except a rapid play of the cilia, which is so violent as sometimes to give an oscillating motion to the animal. This motion continues for a few minutes, when the creature either resumes his speed, or, which is more generally the case, suddenly flies into broken fragments, like the bursting of a grindstone from too rapid revolution. I think the menagerie under the big tent has nothing so wonderful to exhibit as our little Bell animalcule.

"One of the most remarkable species in this family of Infusoria is called the Stentor, or Trumpet animalcule (Plate III., Figs. 11, 12 and 13)—a name to which they can lay just claims from having much the shape of a French horn, as you will readily notice. They are generally found adhering to some fragment of conferva by a pointed foot-stalk. The

mouth is very large and round, excepting on one side, which has a peculiar notch, all of which is surrounded with long cilia in constant play, except when the animal is retracted. They present a rare display of bright colors, green, red, bluish, yellow, brown of all shades, and nearly colorless. Sometimes these are so blended together as to rival the rainbow in brilliancy, transforming the drop of water into a fairy scene of splendor. This you have noticed, I perceive, by calling my attention to what you designate a 'perfect bouquet.' It is a fine group of Stentors in vigorous activity, and if you will watch them for a time, you will see many of them quit their hold and swim away in every possible shape and movement, now mouth foremost and then reversed, or rotating as on an axis, sideway, and in alternate half circles. Its shapes are as various. All these transformations and blendings of colors produce at times an effect similar to the revolving of a Chinese wheel dazzling with its brilliancy.

"The Stentors multiply by eggs and sub-division, which latter process you can constantly see going on. You will mark a splendid Stentor rapidly moving across the field of view, then suddenly stop, turn its trumpet-mouth upward, in which there seems to be a wonderful commotion. Soon there are seen various little buds or protrusions constantly in motion, and

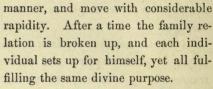
growing larger and larger, each bubble glowing with a different hue as it alternately catches the varying shades of light, bearing, like some already named, though more strikingly, a close resemblance to a rich bouquet, where each leaf and petal trembles in a gentle wind. Mark it still, and anon it will burst into a multitude of fragments: the parent has ceased to exist, but hundreds of children were then born to transmit the ancestral glories to the generations to come.

"I wonder not that you look astonished at such a display of creative power and wisdom, mysterious, transcendently beautiful, and beyond the possibility of imitation, yet as real as are the most stupendous works of God! All these things are but parts of his ways, yet so plainly are they opened to us that we must be self-blinded if we are not led by these minute indices to his footstool who created all these things that he might make his power and wisdom known, and thereby incite us to praise and adore him.

"The Conochilus vorticella (Plate III., Fig. 16) is also a wonder of gracefulness and beautiful mechanism. It is composed of twenty or more little ciliated creatures attached to a hyaline or glassy centre by the usual attenuated thread, each animal being ovoid or cup-shaped, forming a group of exquisite perfection. They are generally transparent, except the

eye spots, which are red, and being slightly tinged with the hue of whatever they live upon. Taken from their cells, they have much the appearance of some species of *Brachionus*, with which they have been confounded by some writers.

"It is a charming sight to notice these globes of Conochilus revolving in such perfect harmony through the water. They turn in every possible



"The Amphileptus and Dileptus are of a different family. (Plate III., Figs. 1, 2, 3 and 4.) They are exceedingly curious creatures. Their bodies are yery flexible, with long lancet-shaped

necks, which they wave around in search of prey, like the motion of a ribbon gently waved by the hand. This long tongue is ciliated to the end, at the root of which there is an open mouth into which it draws whatever may come within its sweep. They are very attractive creatures, from their odd shapes and curious movements. They are mostly found twined with some fibre of algæ, and stationary, but

at times they quit their hold, and backward or for-

ward, it appears to matter little which, they move among their minute fellows, who generally prepare to give them a wide berth. Often they are seen with both extremities turned up like the bows of an Indian canoe, and with a kind of rocking motion make their voyages, bearing no slight resemblance to the above-named vessel, without its dusky occupant. The *Papellous* (Fig. 3) is bristled like a hedge hog.

"The Coleps hirtus (Plate III., Fig. 5), or Barrel animalcules, will next claim some notice. Their slight resemblance to a barrel has given them a name, but

others have more appropriately called them the musk-melon animalcules. They are formed of a cylindrical, hairy body, with blunted ends and corrugated sides, swimming or rolling, as suits their whim. They are very greedy little creatures, and, like the monads, they are found in great numbers



The Coleps Feeding.

around any dead animalcule. They will tear off little bits of the animal, as a hungry dog would the flesh from his bone, which you can see passing into the creature's stomach. When this supply of food cannot be found he will be seen whirling through the water filling his barrel with monads and other living creatures.

"We have also under our glasses several specimens of the Kondylostoma (Plate III., Fig. 6), a long fusiform creature entirely surrounded by cilia. His motions are peculiar and graceful. Sometimes he is seen as a half moon, constantly moving in a circle, and then as a screw winding through the water, or, with head and tail bent upward, he is a gondola graceful as ever rode the waters of Venice.

"But we come to the last object which we shall notice in this connection, and a rare one he is, notwithstanding his long name, which, by the by, is not near as lengthy as himself-the Trachelocerca viridis (Plate III., Fig. 7), or Swan animalcule. In my examination few objects have attracted more of my attention than this one. He has but a very small body, of an oval shape, which of itself is nearly colorless, but wearing the hue of the food which has been swallowed. But what a neck !- long, longer, longest of created things, perhaps, in proportion to the size of the body. The specimens we have under examination are stretched out to a wonderful length, but I have seen them twice this measure. How flexible it is, winding around any object with which it meets two or three times like a thread, or

twisting in and out like stitches. At the far end you will notice a wheel of cilia, by which he draws in his food. I once heard a little girl say, while eating candy, that she wished her throat was twice as long, that she might taste the sweet longer. The Swan animalcule must enjoy this privilege to perfection, for if our throats were as long in proportion, we should have a mile or two of swallow.

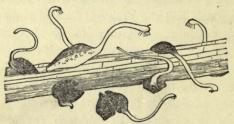
"You notice the little creature swims in either direction, forward or backward, but when he reverses his motion the long neck is drawn in to less than half its length. Often I have met with specimens which had the proboscis doubled at the end, giving two mouths with which to enjoy his food—a plan which, I have no doubt, would suit some greedy boys and girls who live to eat, not eat to live.

"Sometimes these long-necked gentlemen are very pugnacious, and try the process of garroting their victims by winding their proboscis around their necks or bodies, and when their murder is finished leave the body for others to prey upon.

"They multiply doubtless by eggs, which is a process too slow for our purpose, but the other and stranger way of subdivision we can observe with great satisfaction, as it is now going on before us. Notice that cluster around that stem of conferva, especially those seemingly double ones beneath it.

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They are in process of subdivision. In one you can see the neck just protruding, while the original animal turns and twists, as if desirous to be relieved of its burden. Its long neck is whirled around like the whip of a stage driver, or spasmodically entwined around its own body. This state of things will last for some time, when, with one mighty struggle, the separation will take place, and the newly-perfected swan will stretch out his long proboscis and shoot away, while the exhausted parent seems to court a season of repose.



Swan Animalcule Subdividing.

"The beautiful pictures at which we have been looking ought not to be too soon effaced. We will therefore close our afternoon's enjoyment at this point.

"As I came to the school-house this morning I saw the menagerie moving out of town. What little enjoyment it afforded is now only a thing of the

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past, but we have many pleasant hours yet to spend before our resources of pleasure will all have been examined, and as for exhausting them, that is impossible. And herein is one of the greatest wonders which will come under our notice. We can soon exhaust the catalogue of the great animals of the world, but in the small compass of a few drops of water there will be found a sufficient number of varieties to fill the pages of a large volume. I have a Micrographic Dictionary of over a thousand pages, and even that is condensed.

"With all these facts before us, we may claim that our menagerie deserves the highest commendation and patronage, which I hope it may continue to receive from my beloved pupils."

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Euglena, Istasia, and Pibriones.

PLATE IV.

EUGLENA, ASTASIA, POLYPS, AND POLYZOA.

FIGURES

1-5. Astasia.

6-10. Euglena.

11. Diffulgia.

12, 13. Hydra Vulgaris.

14. Plumatella Repens.

15, 16. Eggs of the Christatella.

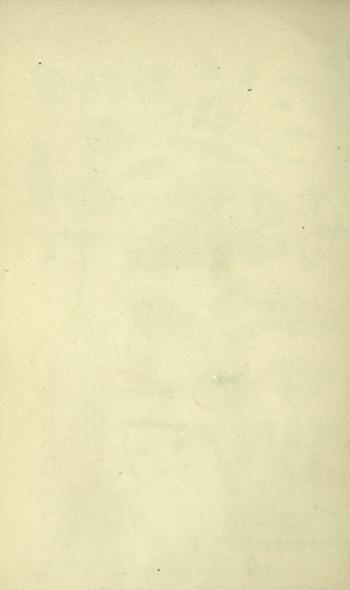
17. Christatella Mucedo.

18. Lophopus crystallinus.

19, 20. Hydra attenuata.



Euglena, Astasia, Polyps and Polyzoa.



CHAPTER VII.

EUGLENA, ASTASIA, AND VIBRIONES.

THE interest excited in the minds of the children by the second day's exhibition was not less than that of the previous day; the objects were so strikingly beautiful and novel. Not only did they learn of the existence of new races of animals, but observed in them such shapes and habits as seemed to bring them into close relation to the floral kingdom. They budded and bloomed, fruited and ripened; were branched with leaf and tendril; and had it not been for their movements, they would have been at once pronounced the flora of the watery garden. And all this in a drop of water, where the unaided eye could detect nothing! They could hardly determine which emotion was stronger, wonder or admiration. Of one thing, however, they were surethey had an increased desire to search farther into this wonderful microscopic world.

In going to and from the school there was much animated discussion among the scholars respecting the marvelous things which they had seen. The thoughtful George Snow could not resist the impulse to tease Tim Allen for his rash censure of his beloved teacher, and so, when they met at the schoolhouse gate on the morning of the third day, George said:

"Well, Tim, what do you think of Mr. Willard's menagerie? You thought you knew all the animals which could be found around Woodlawn, but I rather think our teacher has discovered a few that you had not found out. It will hardly be necessary for him to fit out that expedition to Asia or Africa to enable him to redeem his promise to us."

"Well, now, George, don't say anything more on that subject. I was wrong, and talked like a dunce. I ought to have known that Mr. Willard would not trifle with us, and I'm sure you do not respect and love him more than I do."

"I believe that is true, Tim, and I did not mean to censure you. I know that you've as warm a heart as any boy in school, but you are often too hasty in your conclusions."

"That's so, George, and I never was more aware of it than I am now, and I will try and overcome it. Dear me! I wish I could think before I speak, but somehow the words come right out before I have time to think. But, I say, what can Mr. Willard have to show us to-day? I'm quite sure that he can

have nothing so wonderful as what we've already seen."

"I see, Tim, you're improving fast in forming opinions. But perhaps your resolution has not had time to get settled. You were quite sure Mr. Willard couldn't find anything about these parts which you did not know, in which opinion you were slightly mistaken, and now you are 'quite sure' he has nothing else wonderful to exhibit, in which conclusion it is more than probable you'll be equally mistaken."

"Oh, George, you're too bad to pick a fellow up so. I didn't mean just what I said."

"Then, Tim, you should not have said it. That is just the habit you ought to correct. But, come, let us hurry; there's the last bell ringing."

And away these young friends hurried, for warm friends they were, notwithstanding their difference of character.

Mr. Willard was exceedingly gratified with the moral effect of his experiment on his school. There was an evident improvement in deportment and attention. Some of his pupils began to realize that there is a pleasure in knowledge which more than repays the efforts necessary to obtain it, that even those efforts ceased to be a task, and became themselves a precious part of the seeker's reward.

"I suppose," said Mr. Willard, when, on the following afternoon, he adjusted his instrument to resume his interesting exhibition and lecture, "most of you would have been heartily satisfied with a half day's gazing at the few animals contained in the show which has just left our town, so that, had it remained, few of you would have cared to repeat your visitation. But it is with great gratification that I perceive by your presence and interested manifestations that you are not wearied with the interviews we have had together, and are anxious for their continuance. Perhaps, before we get halfway through with these objects which I am desirous to present, your patience may become exhausted, but I hope otherwise, and shall do my best to prevent any flagging in the interest excited. Our stores yet in reserve are rich with interest, and will last for many days to come, as you may readily understand from the number of objects you have doubtless observed in the water drops already exhibited which have not been referred to. To some of them I shall now direct your attention. In doing this, it is proper that we retrace our steps and begin a little lower down in the order of progression.

"Wishing to divert your attention from what I considered an improper gratification, and create a deep interest in the objects which I proposed to sub-

stitute for the forbidden ones, I have presented you with some of the more striking forms of existence in the world of animalcules. We are cooler now, and can examine our subjects with more deliberation. We will, therefore, resume our investigations with some of the less striking objects found in our collection, only the less attractive from their lacking some of the brilliancy of form and color which we have seen possessed by others. Remember, that which is most showy is not always most valuable.

"First, let us notice those bright green little objects which we find under our glasses. They were obtained by George Snow, being the green and reddish scum which he took from the surface of the stagnant pond, and are called Euglena. (Plate IV., Figs. 6-10.) There are several varieties of these little animals, if such they are, in size about the two hundred and fiftieth part of an inch. They are first of a bright green color, and exist in such vast quantities as to cover large surfaces with a thick scum. Most of the species have what is supposed to be a bright red eye-spot, from which they derive their name. With a high power a long filament like a whip lash is discovered at the head, which is in constant motion, swaying about in all directions, but not seemingly for the purposes of locomotion. While its general shape is a sharpish oval, it assumes a great variety of forms, round, flat, circular, or twisted, being hardly a minute at a time in any one of these shapes. It is amusing to watch them as they dart here and there, tumbling, revolving, dancing, or seesawing through the water.

"Of the manner of propagation and habits of the Euglena little is known with any certainty, the closest observers widely differing in their conclusions.

"It is noticed that the scum, which is composed mainly of these creatures and the Astasia, which we shall soon inspect, at times passes from its bright green to a brownish or blood-red color. Some have supposed that this is owing to the great enlargement of the red eye-spot, while others regard it as produced by the entire change of color in the animal, or the prevalence of one of the species called Euglena sanguinea (Figs. 6, 7) from their bloody appearance. Be this as it may, the fact is well known, and has been the occasion of some alarm to the ignorant, of which fact we shall take particular notice in looking at another object, more intimately connected, as is now known, with this phenomenon. Had our 'wonderful optics' been known, a few of the superstitions of the world would have sooner passed away.

"The Astasia (Plate IV., Figs. 1-5) differ but little from the last named, and are generally con-

sidered as belonging to it. They exist in vast accumulations on the surfaces of stagnant ponds and swamp meadows. Upon a careful examination of these accumulations, they are found to consist of a dense mass of little green atoms full of life and motion. Like the Euglena, they are constantly changing their forms—now a tailless fish, a rolling pin, a cup or ball, a flying dragon, or a shooting star. Often they are seen in a twist like an auger (Fig. 4), and go through the water with a motion corresponding to that of boring with this tool.

"They are said to multiply by eggs and subdivisions, and it must be with astonishing rapidity, when we remember how soon they cover large surfaces after they have once made their appearance. Sometimes a single week will stretch out acres of this green covering over the water. Wonderful little creature! In every foot of that green or red scum there are more of these busy creatures than there are inhabitants on the globe.

"For what purpose these billions of atomic life are created we may not fully understand. They are generally regarded with apprehension as breeders of contagion and death, but if the truth was clearly known, we should probably change our verdict. Like snails and tadpoles, they may be, and doubtless are, Nature's scavengers, to purify the swelter-

ing mass of decaying vegetable matter, by devouring the miasmic poisons, and to send forth to the atmosphere a healthy element. Believing this to be true, let us look at them

'Loving, not loathingly.'

"In these drops of water which we now have under our instruments, you have noticed a vast number of minute objects twisting and turning in every possible shape. They are among the most minute forms which the microscopist has to examine, and their place in the scale is not yet exactly fixed, whether animal or alge. Finding them in connection with the little creatures which we have just been considering, we will not cause them to quit company.

"They seem at first sight but mere attenuated, motionless threads, but when carefully observed the movements already noticed are easily perceptible. Cut off a short piece of spiral silver wire, and you will have the exact form of some of these little creatures; others seem to be pinked, after the fashion of trimming a lady's dress, or to be like a little bundle of filaments bound together by a band near the centre. When under the power of a large microscope, each hair is found to be a more minute bundle or cluster of animals. And it is most likely, if we

could apply a still higher power, these last would be discovered as compound also. They are mostly

colorless or slightly tinged with yellow, except one species, strung together like a string of beads, which is always of a green shade.

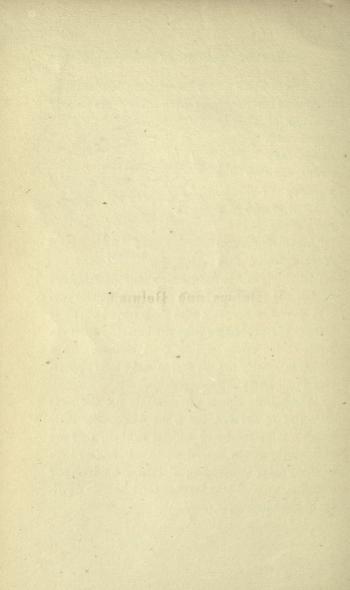
"Like the entire race of animalcules, they



must multiply with an enormous rapidity, as oftentimes ditches and ponds are found to have a bottom covered several inches thick with their remains. Their manner of reproduction is by the breaking up of the joints of the creatures into short sections. They almost invariably are the first to make their appearance in all forms of decomposition.

"These little objects are certainly not the most attractive to the eye, but when we consider their number, minuteness, and curious motions, they are well worthy of our careful study. But as we have so many other things of equal interest awaiting our attention, we must take leave of these humble dwellers in the microscopic world."

10 *



Polyps and Polyzon.

PLATE V.

MARINE POLYPS AND POLYZOA.

FIGURES

- 1-5. Polycystina from mid-ocean.
 - 6. A Spine of the Synapta.
 - 7. A curious portion of a Star-fish.
 - 8. Snake-headed Coralline.
- 9, 10. Sponge Spicula.
 - 11. Hartea elegans.
 - 12. Spirorbis nautiloides.
 - 13. Gamellaria loricata.
 - 14. Salpingia Hassalii.
 - 15. Serpula.
 - 16. Tubularia Dumortierii.
 - 17. Coryne stauriaia.
 - 18. Notamia bursaria.
 - 19. Actinia bellis.

CHAPTER VIII.

POLYPS AND POLYZOA.

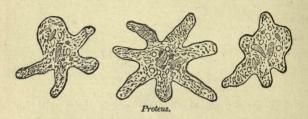
"IN almost all fresh-water ponds there will be found at the bottom very singular minute gelatinous atoms, which, if watched closely, are seen to move slowly about and constantly to change their forms. We have some of them now under our glasses, although they have not attracted your attention, perhaps. If any have done so, I shall be pleased to have you mention it."

"Oh, Mr. Willard," said Sidney Marvin, "I've been watching something here under my glass which was just like that when I first noticed it, but it has been pushing out great long arms in every direction, and then drawing them back again. It is all full of little black specks that run into these arms when they go out."

"Well done, Sidney!" replied Mr. Willard; "you have certainly hit on the right one this time, and a curious subject he is. He has been named the *Proteus*—a title given to one of the heathen gods who

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was thought capable of changing his form and nature at will.



"It is strange that such a shapeless, unorganized mass of jelly should be possessed of any life, much less manifest the existence of marked instinct, but such is the fact-an endowment which it seems determined to maintain. You can see it pushing out its feelers in all directions, securing its food, which it does sometimes by wrapping itself around the object, if too large to be gorged, rather than let it escape. The substance to be appropriated for food may be many times larger than the animal himself, but it is in no wise discouraged by this circumstance. It at once commences the process of wrapping its gelatinous membrane around its victim, as a groceryman would wrap up a parcel for a customer. This, after a while, is wholly absorbed into the substance of the Proteus, showing that this globule of jelly has wonderful powers of digestion. When it has a craving for anything not fully within its reach, it makes a long arm and grasps the treasure. While I have been talking, the specimen under my eye has assumed three very different shapes. In the first form he had but one arm and two or three short protuberances; in the second, six long feelers were pushed out, with a head like a turtle; and finally, he has four strong arms engaged in foraging. And thus he will keep moving indefinitely.

"If you do not wish the trouble of scraping the bottom of some muddy pond to secure a specimen of this anomalous creature, you have only to take a piece of fresh meat and immerse it in a tumbler of rain water for a couple of weeks, and you will then find at the bottom of your vessel a flourishing colony pushing out their arms and feelers promiscuously for your investigation; and, unorganized as it is, it most worthily challenges your careful inspection—a creature that walks without legs; handles, yet possessing neither arms nor hands; navigates without oars or fins; eats without teeth or stomach, and digests its food equally well whether taken internally or by wrapping itself around it; in short, performing most of the functions of animal life without being possessed of one of its perfect organs. It is a paradoxical mass of gelatin, shapeless, yet assuming all shapes—a lump or a wave, a star or a disc, flat or globular, round or square, triangular or oblong.

Its appearance is disgusting, yet confounding the wondering imagination; the most insignificant life of all creation, yet one of the greatest marvels it reveals.

"Akin to this is the Difflugia (Plate IV., Fig. 11), the principal difference being that this last has an egg-shaped shell, out of which its arms are protruded. They are quite numerous and of different colors, owing probably to a parasitic growth, which often covers the whole shell of the animal.

"The family of *Polyps* or *Hydras* will now claim our attention, and a most interesting study we shall find them, as they present to the eye some remarkable forms and colors. Sometimes they appear like a 'green palm tree' with golden-tipped branches, and anon change into a brilliant star as they suddenly contract their bodies. Now they are like the tesselated appendage on the turban of a Turkish pasha, or the blazing fuse on a grenadier's cap. They open and shut like a sensitive flower, coil their long tentacles around their prey, or hang pendent, waving like silken threads.

"Observe those long clusters of thread-like appendages (Plate IV., Figs. 19 and 20) looking like a minute cat-o'-nine tails—an instrument which many a poor sailor boy has learned to dread. They would seem at first sight to be mere fibres of conferva, but

a few moments' watching will show those tentacles suddenly contracting, as some victim comes within their sweep, and a fatal snare he will find them. Like the arms of the cuttle-fish, they are wrapped around the object so closely that there is no escape, and are strong enough to hold worms and insects many times larger than the little Polyp who owns them. But this is not all of their fatality, as they are armed with a number of sharp stings which penetrate the hapless victim, infusing, as is supposed, a deadly poison in the wounds which they have made, or, as others believe, like the electrical eel or torpedo, destroying their prey with violent electrical shocks. It is only by some such method that the speedy death of the victim can be accounted for. Be this as it may, the struggle is soon over, and the Hydra enjoys his meal at his leisure

"Here is a little cluster of Lemna, pendent to

whose roots can barely be perceived some bright green little starshaped objects. Let us detach some of the mass and put it under our instruments. Thus arranged, we can at first see only three or four roundish green objects, but



Lemna with Polyps.

wait a few moments, and we shall be rewarded by seeing the Polyp stretch himself when he has re-

covered from the fright we gave him. There he comes, slowly, as if yet apprehensive of danger—larger and larger. There! we have the perfect palm tree, or rather the perfect Hydra vulgaris (Plate IV., Figs. 12, 13), with the embryo of his race growing from the side of the parent. These youngsters will soon push out their long arms, and when thus able to take care of themselves will sever their connection with the parental stalk and set up for themselves. This is the more common species found in our freshwater ponds and streams, especially where Lemna or 'duck weed' is found growing.

"The Polyp, in taking its food, is like the Proteus; it matters not whether it is swallowed or wrapped up in a fold of its tentacles, it is just as easily digested; nor does it matter, indeed, whether the creature is inside out or not: it is all the same. He does not, like some of us, mind being cut up. Sever him into as many pieces as you like, each fragment remedies the damage by putting out a new head and tail, and going to work as usual, as much as to say, 'Try it again!' If you sever him lengthwise, the two halves close up, and just as readily repair the injury. But stranger still, you can cut off the heads from ten individuals and exchange them, and the subjects of the operation do not seem to mind it at all; each takes his neighbor's head and grows to it. I think

this feat rather surpasses anything exhibited in the great menagerie, and although we have not the time to verify it now, you can see it done when you have learned the use of the instruments sufficiently, and can give it the necessary attention. This animal's life, therefore, is almost proof against everything but heat and acids.

"The *Polyzoa* are near relations to the *Polyps*, but having their houses in a shell or calcareous covering, they are placed among the *molluscs*.

"Of this family there are but a few species found in fresh water, but these are of the most interesting character, from their bright colors and graceful movements through the water. Their beautiful display of feathery tentacles arranged in a semi-circle will also attract marked admiration. From the peculiar shape of this last-named appendage, they are classified as *Hippocrepia*, or horseshoe-like.

"Of this class one is called the Cristatella mucedo. (Plate IV., Fig. 17.) It is not often met with, but I am fortunate in having found a source of supply during all the summer, and not being sure that you had made any captures in your expedition, I have brought some, which I will now put under our glasses.

"There he is, a most exquisite little fellow, moving gently just under the surface of the water. His

crown of graceful plumes is waving in the light, making a picture which we may well gaze at with admiration. Its principal food seems to be the desmids and algæ floating around it. It is always regarded as a most exquisite specimen of minute life, and will repay a careful searching after.

"The eggs of this little creature are scarcely less beautiful than itself. (Plate IV., Figs. 15, 16.) They are not larger than a small pin-head, of a dark red color, and have a peculiar fringe of hook-pointed spines around the edges. They can be found by very careful searching with the instrument among the masses of algæ from which the parent is taken.

"The Lophopus crystallinus (Plate IV., Fig. 18) has much of the appearance of the last named, except that it is double, and therefore presents a more gorgeous object to the eye. Its crests of graceful plumes are arranged in double horseshoe shape, two of which are fully expanded, the smaller enclosed ones being the buddings for a new generation, by which it multiplies as well as by eggs.

"The last of these splendid objects which we can examine is the *Plumatella repens*. (Plate IV., Fig. 14.) It is more common than the two just named, though from its generally choosing the under side of some aquatic plant, it escapes observation unless carefully sought after. It is seldom or never found

detached and moving through the water, and is very timid, withdrawing into its cell on the least disturbance.

"With these beautiful objects before the mind, and the sublime thoughts which they are so well calculated to awaken, let us close our third day's exhibition. But as our catalogue of curiosities is not nearly exhausted, it is proper for me to ascertain whether your interest in the study has so far diminished as to cause you to wish that it should conclude here; and I know of no better way to determine this than to bring it to a vote. I will most cheerfully abide by your decision, whatever it may be, and as I particularly desire that it should be a frank expression of your real sentiments, I shall pause a while to give you time for reflection while I am putting up the instruments. Make up your minds, and then you can vote just as you feel without fear of offending me, although you may indicate thereby my failure to interest you as I have intended. Should any thus indicate their disappointment, I shall most cheerfully excuse them from further attendance at these examinations.

"Well, are you all ready? All those who truly desire me to continue these microscopic examinations will hold up their hands."

The hands all went up with a will.

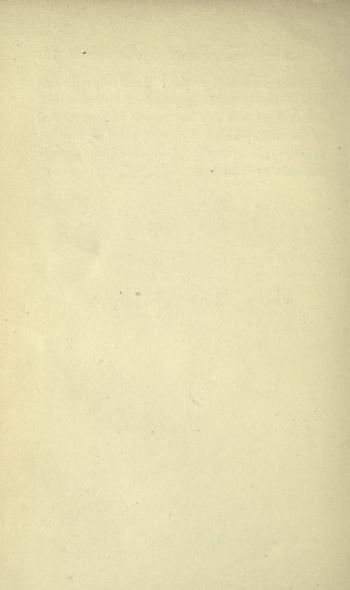
"That will do, and I am very much gratified to notice that every hand went up as though you meant it. I need not assure you that I will do the best I can to repay your confidence.

"And now, a word or two before you are dismissed. We shall have an intermission of three or four days, during which I expect to visit the seashore, where there can always be found objects of the rarest interest to the microscopist, especially in the department which we have just been examining. I shall improve the opportunity to make the best collection I possibly can, and on the first afternoon after I return you shall see the results.

"These beautiful objects will teach us that God in all parts of creation has scattered such specimens of his handiwork as to leave no doubt of his omnipresence. Go where we may, he is all around us, not only in the grandeur of the mountains or dark heavings of the ocean, and in the visible things of creation, but also in the dust of the desert and slime of the bog, when penetrated by the wonderful instruments we are using. Gems of form, brilliant penciling of color, and marvelous conditions of life startle us by their presence. Wondering and awed, we can but exclaim like Jacob at Bethel: 'Surely the Lord is in this place, and I knew it not!' You may ask, Why were these things thus created and hidden away

GREAT WONDERS IN LITTLE THINGS. 127

from our common inspection? I can only reply that so it pleased God. It may be for the purpose—and the thought is a sublime one—of putting the seal of his infinity wherever the eye, aided or unaided, could pry into his works. God is in all, and through all, and in you all."



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CHAPTER IX.

MINUTE WONDERS OF THE SEA.

THERE were few of the delighted youth who wended their way home that afternoon but coveted the privilege of accompanying their beloved teacher to the seashore. Living so near it, most of them had visited it often, and had spent many happy hours roaming along the beach, picking up shells and turning over jelly fish, but a day or two at Brigantine, in company with Mr. Willard, would be a treat indeed. If he could find such wonderful and beautiful things in muddy ditches and slimy ponds, what marvels would he not search out on the shores of the great ocean? Many a parent was solicited for such a favor, as Mr. Willard had expressed his willingness to take in charge any of his pupils who could obtain permission to go with him. Alf Green, Willie Hunt, and Nettie Newton were so happy as to obtain this gratification.

Their outfit was much the same as that used by the children in their grand expedition, with the addition of one of the microscopes and a small single lens for examining the larger objects on the shore.

It was a happy time for the three favored children, especially for the sharp and inquisitive little Nettie. She cared but little for dress or the gay company which she met at the watering-place, and even the grand old ocean did not exert its usual spell over her imagination. She was impatient to pry into its secrets. Her feminine curiosity had been excited, and she could hardly wait until Mr. Willard arranged for their stay at the hotel, so impatient was she to get to the shore for a ramble, and to hunt for its rich treasures. The two boys were scarcely less enthusiastic. Nor was their friend and teacher annoved by their impatience, which he did not put to a too severe trial. Taking his requisites, they all repaired to the beach and began their researches. It was wonderful, with their quickened senses, how many things they observed that had never before attracted their attention. A few large shells, a king crab, broken star fish, or a stranded jelly fish had usually been the sum of wonders which they had found. But their eyes were sharper now, and, without the aid of the smaller instrument, they were not long in making some rare discoveries. Nettie was the first to arrest attention:

"Oh, Mr. Willard, I've found a tiny little bead; some lady must have lost it here, and perhaps we can find some more."

Mr. Willard put it under his small glass for a moment, and then handed them both to Nettie, who gave but a single look, when she fairly jumped with raptures.

"Oh, isn't it beautiful! It's all over speckled, and there's a hole clear through it. It is a bead, isn't it, Mr. Willard?"

"Well, Nettie," replied the teacher, "it does very much resemble a bead, but beads do not often live,

and this one was full of life once. This is the broken shell of an *Echinus*. There are many of these beautiful creatures now living in the sea and along its shores, but a far greater number

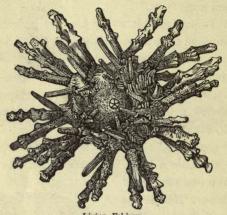


Echinus with Spines removed.

are found in a fossil state. They are orange-shaped, and when alive they are covered over with long and curiously-jointed spines. These arms are fitted in a socket-joint, and can turn in any direction. With these spines the animal works himself into his burrow in the sand and captures his prey. As the fossil state would indicate, this creature was well

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known centuries ago, being called by the ancients the 'Lantern of Aristotle.'"



Living Echinus.

Hardly had Mr. Willard finished describing Nettie's prize, when Willie Hunt discovered in a little heap of decaying seaweed an object which arrested his attention, and he cried out lustily:

"Oh, come here, all! I've found the prettiest thing! It's a little bit of a ball, with five mighty long arms."

"A Daisy Brittle Star," said Mr. Willard after a moment's examination, "and a very beautiful specimen too. Look at him through this glass, and you will then discover that those long tentacles are made up of short joints with little pin-holes between them,

GREAT WONDERS IN LITTLE THINGS. 135

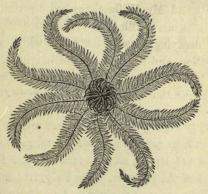
through which the animal protrudes a multitude of

sucker-shaped feet, which by count amount to more than five thousand. With these sure members it can glide over the smooth surfaces of perpendicular rocks and creep along the soft bed of the ocean. This beautiful process



you can only see by placing your little captive in a glass vessel, where he will soon expand his long arms and go feeling about.

"Perhaps the most beautiful member of this family of stars is the Rosy-feather Star. In this grace-



Rosy-feather Star.

ful creature the arms are increased to ten, with the feathery edges much prolonged, giving them a beautiful plume-like appearance. These sea stars often have a rich red or pinkish color, which adds very much to the interest of their examination. They can almost always be found in the little basins of water left when the tide goes out, from which they manifest but little disposition to escape. From these hiding-places we must capture some to exhibit to the school when we return, for it is one of the most pleasing circumstances of our accumulation of knowledge that our own enjoyment is greatly enhanced by communicating our riches to others. Besides this, which may be regarded as a selfish motive, knowledge always brings a responsibility—an obligation to instruct others.

"But I notice that friend Alf has found something that seems to attract his attention. What is it, my boy?"

"I can't say, teacher, but it looks something like those green Polyps which you showed us in your last lecture."

"Yes, you are quite right; it is a marine Hydra, but much larger and of a brownish orange color. Its tentacles are longer, and are formed much like the branches of the sea stars. The body, like the freshwater Polyp, is very flexible, and is drawn up and

expanded at the will of the animal. There are many varieties and sizes found in the sea, being doubtless connected with the coral family. Like his fresh-water relative, an embrace from those long arms is fatal to any poor victim coming within their reach; it will be securely held, and its life sucked away.



"But look at this magnificent leaf-shaped Sertularia or Sickle Coralline which I have captured in this bunch of algæ.

"It has the general shape of a leaf, but each one of these little branches is separate from the rest, and is strung full of little cup-shaped brown Polyps. It is a rare beauty. And mark what touchy little fellows those Polyps are: shake the branch ever so



little, and every brown head dodges back into its cell with a sudden jerk, to be almost immediately protruded again."

Thus, one after another, some curious thing was found, examined, and when capable of being preserved, treasured up for

future exhibition to the school. No wonder that the three days passed away so quickly to the young enthusiasts, and that they were reluctant to leave the scene of so much enjoyment. But then, to make amends for this necessity, they had a rich store of rare things to take home, and a whole budget of wonders to relate. On their way home it is more than probable that the youthful members of the party felt a little vain of their new accomplishments, with a lurking intention of showing off their superior wisdom among their less fortunate school-fellows. But when they were once more among the familiar

group, they felt so happy in telling of their trip that all pride was gone, and they nobly did their best to make their mates partake as much as possible of their pleasure.

The first afternoon after Mr. Willard's return was waited for with great expectation. They well knew that he would not return empty handed, but the enthusiastic reports of his young attendants had whetted their desires to the utmost sharpness. When, therefore, the happy hour at last arrived, the teacher was surrounded by an anxious band craving to behold the wonders which he had gathered from the shores of the great sea.

After the cordial greetings had been exchanged, Mr. Willard lifted a large wicker-basket to the table, and took from it his jars and boxes containing his specimens, and then adjusting his instruments, he said:

"Children, I am happy to meet you again, and to exhibit to you the treasures which we have collected during our visit to the seashore; and I am sure, if you enjoy this inspection with half the satisfaction which we experienced in obtaining them, you will have no occasion to regret the opportunity.

"The microscopic objects of the sea are much more numerous than those of the land, and are generally of a more striking and beautiful character. Of these thousands of unique forms we can examine but a few, but these will be amply sufficient to excite our highest admiration. Most of these marine wonders are of a size to make them perceptible to the eye when carefully sought after, but their surpassing splendor can be brought out only by the aid of the microscope.

"We have already had our astonishment excited by the incomprehensible myriads of animalcules swarming in ditches and ponds. But how limited are these dwelling-places of minute life compared to the great and mighty ocean covering more than two-thirds of the surface of our globe! 'As you had no conception of the crowded life of a drop of water taken from the ditch until you looked at it through these instruments, so you have no doubt supposed, as you looked at the clear blue waters of the ocean, that all its broad expanse was free from any mixture save the scattered members of the finny tribes. So it seems to the unaided vision, but a look into its waters through our wonderful optics reveals the same teeming profusion of animal existence that we have found elsewhere. Not only along its shore and in shallow waters, but through its broad expanse, we can skim them from its surface, dredge them from its deepest bottom, with seven miles of waters above them, and strain them out everywhere-singly, so

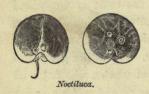
minute as not to be perceptible, but collectively giving color to hundreds of miles of the ocean's surface, tinting it green by day and covering its billows with coruscations of flame at night, and, withal, feeding to unequal fatness the hugest monsters of the deep! Who shall say to the Holy One, Thou shalt not go beyond this greatness? or, This is so small thou canst make nothing less?

"All climates are peopled by them. They are found in the everlasting ice of the North, or the evertepid water of the South. Captain Scoresby found that the waters all along the coast of Greenland were discolored by animalcules so minute that one hundred and fifty millions would find abundance of room in a tumbler of water. It was the green pasture-ground of whole herds of whales, who fatten on its richness—God's gracious provision for a region where the seal of eternal ice keeps shut the door of Nature's other storehouses.

"Through the long night of months in that latitude they often relieve the gloom by their phosphorescence, tipping the briefly appearing waters with the show of heat, by which, perhaps, the poor benumbed sailor may in imagination gather a little warmth.

"Mr. Darwin found them equally as numerous and brilliant while sailing near the mouth of the

river La Plata. The vessel, he says, drove before her bows two billows of liquid phosphorus. In passing down the Chesapeake Bay I have often sat up half the night to observe the same beautiful phenomenon. Mr. Gosse has observed this brilliant exhibition in a salt-water aquarium by tapping the glass with his finger, when suddenly there would be on the surface minute sparks of light. This he discovered to be produced by the tiny Noctiluca Miliaris. They were very delicate and colorless, except when shaken; then they emitted their light as they



made a dive toward the bottom. They are curious little bodies, not unlike the outline of a cherry, floating on the surface of the water like the Nau-

tilus, anchored by a little filament hanging beneath the water.

"From this great sea, wherein there are 'both small and great beasts' innumerable, we can, of course, select but a few which we have picked up on the shore, which you shall now inspect, with a few other forms secured by other hands in more distant places, which I have procured for your gratification.

"And first, let us admire these elegant *Polycistina* (Plate V., Figs. 1-5) obtained by Major Owen by

dredging the surface of mid ocean. Beautiful in form and color, and of the frailest construction, they rock and toss on the stormiest wave in perfect safety where the proudest structure of man is dashed to pieces, secure in their very frailty. The storm may not wreck them nor the ocean's depths be their sepulchre until God's purposes are served by their unobserved existence.

'Full many a gem of purest ray serene
The dark unfathomed caves of ocean bear.'

Are ye not much better than these? He who protects them watches especially over you. Never think of God as seeking occasions to inflict some terrible example of his power and wrath upon you. With more than a parent's love and solicitude he makes all things work together for good to those who love him.

"Here is a splendid specimen of the Hartea elegans. (Plate V., Fig. 11.) A graceful cylindrical column, surmounted by a rich cluster of tossing plumes, and just above it you will observe a curious half of an egg with the head of a goose: it is the spine of the Synapta, or Sea cucumber. Just at the right of this queer object is the elegant portion of a sea star. At the right of this last-named specimen we have the Snake-head Coralline. They are

ugly, ghastly-looking creatures, with their heads waving to and fro, as though wishing to escape. When more largely magnified, the snaky resemblance is more complete, as there seems to dart from



Head of Snake Coralline.

his mouth a number of forked tongues. We will let him pass, and look at something more agreeable.

and here it is, a beauty—the Spirorbis (Plate V., Fig. 12), a little milky-white shell, out of which is pushed a tuft of beautiful pink-colored plumes. It is quite perceptible to the natural eye, but must be under a low power at least to appreciate its richness.

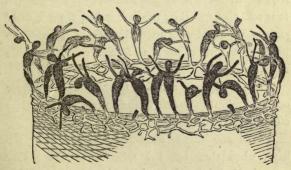
"We have several species of branching polyps, as Gamellaria, Salpingia, and Notamia, or Shepherd's purse. (Plate V., Figs. 13, 14 and 18.) All these are beautiful and plentiful, but we must pass them by, as more attractive subjects are waiting for our inspection-the Serpula and Tubularia. (Figs. 15 and 16.) These splendid creatures live in shells, protruding therefrom a great crown of feathers, which wave and curl with most attractive gracefulness.

"The delicate flower-looking object is the Coryne (Plate V., Fig. 17), an object which ever holds the eye of the observer. At the mouth of the little bud, attached to the long white thread, are four curious

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pins, standing out like those in the hair of a Japanese lady.

"We have many specimens of the Actinia (Plate V., Fig. 19), but time will not permit us to particularize, as I have one rare object to show before we close this interview. It is not because of its great beauty, for it can boast of little in that line, that I present it to you for your inspection. It is one of the greatest oddities. Think of a large caldron, around the brim of which a whole band of wild Indians and pappooses are dancing and gesticulating in the wildest and oddest manner, and you will have the best idea which you can get without looking at the reality. The ludicrous scene will be better appreciated if it is remembered that the caldron is inhabited by a distinct creature, which these animal-



Lares around the Mouth of the Sabella.

cule Indians, seem to be threatening with such terrible demonstrations. Here it is, boys, and a rich treat, too, as it is not often met with.

"I wonder not that the poor Sabella who owns the house has withdrawn into his citadel to escape from such a hideous band. Watch how they bow and twist backward and forward, and shake hands, as though exulting over an easy victory. But like many of a much higher race who are alike given to noisy assertions of courage, only let the entrenched enemy show his head above the walls, and all these threatening savages subside into quietness, ready to renew their harmless demonstrations as soon as he goes out of sight again. We have a rare text for moralizing, but as I am quite sure that you can draw the inferences without a discussion on the subject, I will leave it for you to make the application. It is said that 'wisdom can be learned from a fool.' and so we can gather truth from the laughable aspects of nature, as well as from her incomparable realities.

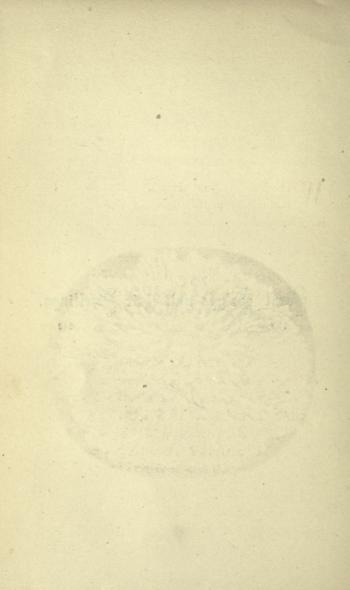
"We shall have occasion to spend another hour over the minute wonders of the sea, and so will close our pleasant interview at this point."

It was one of the most natural things for the boys, when they left the school-house, to gather around the brink of an old hydrant cistern which was uncovered for repairs, and with joined hands dance around it in imitation of the grotesque lares. This they were doing with great merriment when the teacher passed on his way home. He could not help smiling at the aptness with which his little friends appreciated the odd exhibition which they had just witnessed, nor did he desire to repress their exuberance, not deeming it necessary for the proper formation of character that the face should always wear a solemn look and every disposition to mirthfulness be repressed. He, therefore, in passing them, very pleasantly remarked:

"A very good imitation, boys; I did not know that you could so easily convert yourselves into little Indians. I rather suspect if the policeman should appear you would vanish as quickly as the lares do on the appearance of the poor Sabella."

"We can do that without his appearance," said Alf Green as they scattered merrily to their homes. Coral Holppe and they Obrelian

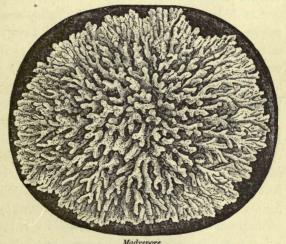
Coral Polyps and their Dwellings.



CHAPTER X.

CORAL POLYPS AND THEIR DWELLINGS.

HEN the children again assembled around the familiar table they found it covered with a large number of specimens of coral of different form-



Madrepore.

ations, while on a small black marble stand there rested a magnificent cluster of Madrepore.

Mr. Willard began the exercises by saying:

"As naturally following the interesting study of minute sea life which we had yesterday afternoon, we will take up the coral polyps and their wonderful dwellings, not the less beautiful in their forms, and far more stupendous in their operations. They have helped to build up and shape the globe on which we dwell, and with a ceaseless energy and toil are still producing marvelous changes that stagger the imagination.

"As it is very difficult to obtain living coral polyps so far from the seashore, we shall have to satisfy ourselves with a description of the living animal, but their splendid palaces we have before us, and can carefully inspect their wonderful architecture.

"The polyp family vary much in size and color, but have the general characteristics of a rounded or cylindrical body, the mouth surrounded by a number of flexible tentacles, which are retractile. The body is soft and capable of great extension, often protruding several inches from the home cell. Hence many of them can be examined with the unaided eye, but a low power is requisite to fully comprehend their curious structure and habits. They propagate in three ways—by subdivision, the deposit of eggs, and by budding, which is perhaps the most common.

That they increase with great rapidity is evident from the rapid growth of their dwelling-places. Look at this splendid bunch of coral on the standone of the finest I ever saw. You can perceive with the natural eve that each one of these numerous branches is filled with numberless minute holes, constructed with remarkable regularity and exquisite workmanship. In each of them one or more live polyps has made his dwelling and worked out his destiny. We will place a small fragment of one of these branches of coral under our instrument. with a high power, and you will see a gem of very rare workmanship, surrounded by a wreath of the

most delicate structure. What myriads of these exquisite chambers there are in this single specimen! Imagine them all inhabited, and each minute occupant ascending to the battlements of his enchanting

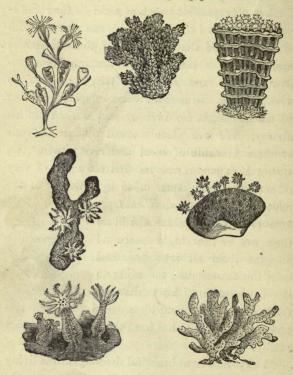


castle and spreading out his graceful banner of tentacles, and you will but have the picture of a past reality.

"I have here some beautiful drawings of the living polyps protruding from their cells. In one, the Cydonium, the tentacles are broad and feathery, like the sea daisy, while others are star-like, as the Tubipora or Gorgone. The Tubipora is a very curious coral,

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often called the *organ-pipe coral*, from its striking resemblance to a bunch of organ-pipes. When these



tubes are occupied they have a polyp of a bright green color, seeming to the observer a gelatinous mass, which the microscope resolves into a confluence of the myriads of inhabitants. This species abounds in warm seas, especially in New South Wales, the Molucca Islands, and the Red Sea, which it is fast filling up with its ceaseless industry.

"The Alcyonium is a well-known species, called by the Germans the 'thief's hand,' and by others the 'devil's thumb,' with other similar odd names. It is, however, not as



Alcyonium.

ugly as these names would indicate, but is really a delicate and beautiful object when seen with its occupants all expanded over its surface.

"With this brief sketch of these wonderful little architects, let us take a glance at their magnificent structures. These are different in form and texture. as you can see, varying in shape from the graceful tree to the thumb-shaped projection, the wreathed circle, the flowery disc, the wicker basket, and the netted oval, and in texture from compact limestone to the most open filagree. In color they are most generally of the purest white, but are occasionally seen of a soft pink or emerald color.

"Mr. Dana, who devoted much time and careful attention to the corals of the Pacific, where they abound in the greatest profusion and perfection, thus writes: 'They form trees of coral, and although not emulating the oaks of the forests-for they do not

exceed more than six or eight feet in height-they are gracefully branched, and the whole surface blooms with coral polyps in place of leaves and flowers. The cactus, the lichen clinging to the rock, and the fungus in all its varieties have their numerous representatives. Shrubbery, tufts of rushes, beds of pinks, and feathery mosses are most exactly imitated. Many species spread out in broad leaves or folia, and resemble some broad-leaved plant just unfolding. When alive the surface of each leaf is covered with polyp flowers. Besides these forms imitating vegetation, there are gracefully-modeled vases, some of which are three or four feet in diameter, made up of a net-work of branches and branchlets and strings of flowers. There are also coral hemispheres, like domes, among the vases and shrubbery, occasionally ten or twelve feet in diameter, whose symmetrical surface is gorgeously decked with polyp stars of purple and emerald green.'

"But the beauty of these coral sprays, and the brilliancy of their colors, are lost sight of when we think of the sublime magnitude which they present as a whole, and of the insignificant workmen who have built them up into islands and continents. When we reflect that those vast coral reefs which form New Holland and the whole group of islands in the Pacific Ocean were built up from almost un-

fathomable depths by the labors of these minute polatys, a little oblong bag of jelly, varying from the smallest atom to the size of a pea, we may well pause and ask, 'Can these things be so?' We cease to wonder at a few millions of monads in a drop of water: a greater marvel is before us—a tiny creature building up continents and ocean barriers, blocking up the march of progress, and wrecking mighty navies. We cease to wonder at insignificance, and stand trembling at the dangers which it builds up before us.

"What myriads upon myriads of these little creatures have toiled for untold ages beneath the deep, deep sea! It eludes all attempts at calculation, and imagination shrinks from the effort to compass it. They have done what man would attempt in vain to accomplish, damming up the paths of the sea and saying, as with the voice of Omnipotence, 'Hitherto shalt thou come, but no further, and here shall thy proud waves be stayed.'

"The Polynesian Archipelago, now denominated one of the great divisions of the globe, is the upbuilding of these little zoophites. On the coast of Australia the Great Barrier Reef stretches for more than a thousand miles. Some groups of coral islands in the Pacific are longer still, reaching to twelve or fifteen hundred miles in length by three or four

hundred in breadth. And all this work of worldbuilding done by an animal barely possessing life, cemented to a narrow cell, and ephemeral in existence! Guided by the divine wisdom and aided by the almighty hand of God, it goes on mapping out its submarine foundations and building up from the ocean's deep valleys new worlds for man's inhabiting! What are the proudest monuments of man's skill compared to this ocean masonry? What is an elephant or a lion compared to such a creature as this? Ocean storm and grinding keel may often destroy in a few hours the patient work of centuries, but the brave zoophite is not discouraged. He stops not to mourn over the ruin, nor to anathematize the spoiler of his labors, but at once addresses himself to the task of restoring the wreck to order and symmetry. He seems to have learned the lesson long before our voices had been tuned to sing it:

> 'If at first you don't succeed, Try, try again,'

and most faithfully has he profited by it.

"We are also impressed with the great virtue of unselfishness. The little polyp that laid the foundation of one of these ocean continents ten or fifteen hundred feet below the surface of the deep began his labors not only to meet the necessities of his own brief existence, but for a posterity which should come many thousand years after his ocean masonry was completed and he himself absorbed into the superstructure which he had helped to build up, yet he faithfully served his day and generation, gathering in from the watery wastes around him his atom of lime, and gluing it to the ocean's bed, fashioning out his little home cell, which was to serve equally for his dwelling, his sepulchre, and his monument.

"The same God who gave the coral worm a work and inspired him with patience and industry to complete his task has given to each of you a higher vocation, but instead of leading you by blind instinct to fulfill the purposes of your creation, he has endowed you with reasoning faculties that you may prove yourselves worthy of his great bestowal. You are to develop and apply your superior endowments to the noblest purposes of truth, benevolence, and religion. You are not here to build great monuments of labor, produce marvelous physical changes, and then to die, but to 'glorify God and enjoy him for ever!' He who crowns the labors of the insignificant coralline with such wonderful results has especially promised that you shall not labor in vain, nor spend your strength for naught. Only apply your energies to noble pursuits, and press on with unfaltering assiduity, and 'in due time you shall reap, if you faint not.' You may not help to build up continents from the bosom of the deep, nor stretch a barrier across the ocean pathway, but you may help to deck the one with verdure and bring to its inhabitants the blessings of knowledge and religion, and build on the other the beacon-light which shall guide the mariner away from its dangers. You have something to do, and do it faithfully:

'Choose well the path in which you run,
Succeed by noble daring;
Then, though the last, when once 'tis won,
Your crown is worth the wearing.
Then never fret if left behind,
Nor slacken your endeavor;
But ever keep this truth in mind—
'Tis better late than never!'

"Of these polyp dwellings there are three or four different styles of architecture. One of the most peculiar is called the Atoll. It consists of a circle of coral formation enclosing a shallow lagoon. This circular reef rises just above the level of the sea, spreading out to the breadth of a quarter of a mile or more, on the outside of which the water has great depth, but within growing less and less until it all disappears. In this how marked is the divine agency! God is the great superintending architect.

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The little polyp works to propagate his race, but the purpose which God has in view is the building up of a new habitation for man, using these minute toilers of the sea to accomplish it rather than to speak the word which would give an instantaneous result. But these little workmen would toil in vain were their frail structure exposed constantly to the direct action of the ceaseless ebb and dash of the



A Coral Atoll.

ocean. Not only would their direct labors be destroyed, but the algæ and other vegetable growth necessary to form a soil would be swept away. But God directs his little workmen to form their circular wall, and calmness settles over the face of the waters within, where pastures of algæ grow, decay, and leave successive strata of rich sediment until the dry land appears and verdure covers the surface.

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"The Barrier Reef, as another class of coral formations is called, illustrates the wisdom of this circular protection. These remain much the same for ages, the waves sweeping over them during storms or high tides, unless God, by some other wonderful agency, lifts them up above the ocean friction.

"A writer, in describing the action of the surf on the Great Barrier Reef on the north-east coast of Australia, gives a vivid picture. He says: 'The long ocean-swell being suddenly impeded by this barrier, lifted itself in one great, continuous ridge of deep blue water, which, curling over, fell on the edge of the reef in an unbroken cataract of dazzling white foam. Each line of breakers ran often one or two miles in length, with not a perceptible gap in its continuity. There was a simple grandeur and display of power and beauty in this scene that rose even to sublimity. The unbroken roar of the surf, with its regular pulsations of thunder, as each succeeding swell fell first on the outer edge of the reef, was almost deafening, yet so deep-toned as not to interfere with the slightest nearer and sharper sound. But the sound and sight were such as to impress the spectator with a consciousness of standing in the presence of overwhelming majesty and power.'

"These scenes are truly grand, but they are much oftener the occasion of overwhelming fears, when, amid darkness and storm, the poor mariner hears the thunder of their dashing. The wrecks which lie around them are abundant proof that his fears are well grounded. They are the terror of ocean navigation, yet the goodness of God is seen in slowly lifting them up for man's dwelling-place, and often shaping them into a harbor of safety, where the sailor can drop his anchor.

"The little polyp cannot carry on his masonry above the surface of the water; hence, when he has reached the surface, other agencies must complete the work which he has thus far advanced, or it remains a new danger in the pathway of man. But God has abundant resources. If his designs are to be developed slowly, new forms of life and vegetable growth work out his sovereign will; but if more rapid agencies are required, the earthquake or volcanic fires lift up by one mighty throe the submerged continent or beetling cliff. Thus God combines the weakest and mightiest forces to complete his vast designs.

"In our own country the Florida reefs are an illustration of these coral wonders. Look at your maps, and you will see extending out from the southern point of that State, many miles in length, a succession of small islands called the Florida Keys. These are the work of the coral polyp; and, busy

still, his work goes on, building up and extending out the borders of his populous city.

"A recent writer in Harper's Monthly Magazine, who accompanied a party of engineers making a survey of the Keys, gives a very interesting account of their formations. They are described as being raised some two feet above the water, and formed of several varieties of coral, the process still going on with great rapidity. So soon as there is the least appearance of dry land at low tides, God has provided a wonderful tree to root itself in the soil and form a nucleus of vegetation—the mangrove.

"See the wisdom of this provision. If the seed of this tree was like a chestnut, or other dry-land species, dry ground must appear before it could propagate. But the seed of the mangrove is long, cigar-shaped, and starts the germinal leaves before it drops from the parent tree. When it at last is free it drops into the water, with half of its length beneath the surface, with little rootlets feeling about, ready to grasp the first bottom that may be touched. Here it roots itself and grows, spreading out into a grove while yet the water is above the coral formation. But the nucleus of an island is formed, and time will enable the various agencies to build it up to the sunshine. The ways of the Almighty are wonderful. That mind must be dull which does not per-

ceive his wisdom, and that heart cold indeed that does not reverence him for his goodness and his wonderful works.

"Our roaming amid the coral groves has been very delighful, and has attractions which might detain us for many an hour longer, but our allotted hour has expired, and we must take our leave for the present of the minute wonders of the sea."

The children left the school-

house that evening in quite a different mood from that manifested the day before, when they imitated the grotesque lares around the broken cistern. They were excited, but thoughtful. They began to comprehend the bearings and lessons of the subjects which their teacher had so skillfully brought before them. An awe of God, never realized before, seemed to



Mangrove Seed taking root.

pervade their minds. It held in an impressive silence their youthful lips, so ready to give utterance to long pent-up emotions when relieved from the restraints of the school-room. That oft-repeated text came to many of their memories, "Thou, God, seest me," with a new meaning, and their secret sins began to trouble the conscience as they realized how plainly and comprehensively they were all known to God. Many a good resolution was doubtless made to refrain from further offending him who could "set their secret sins in the light of his countenance." Small acts, whether good or bad, were comprehended in a new light. They were seen to have a relation to every other act, shaping and coloring the whole tenor of life. The whole is but the minute parts united.

The earnest, loving teacher saw all this, and rejoiced that his labor had not been in vain.



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CHAPTER X

ANTERNA

Wiften the children were again assembled the coveted afternoons treat, who coveted afternoons treat, who materials and began a fance we last explored out futle drop of the rater, we have made rather a long and extent to age fiver the ocean, inspecting the coral islant the facility and rest bound shores at New Hand and Australia. We have found many object absenting interest though, contrary to the using each outsire where the minute forms are confining ourselves to the minute forms as a mater where the minute forms are material and material and minute forms are minuted and minuted forms.

CHAPTER XI.

ANNELIDA.

WHEN the children were again assembled for the coveted afternoon's treat, Mr. Willard arranged his instruments, and began:

"Since we last explored our little drop of ditch water, we have made rather a long and extensive voyage over the ocean, inspecting the coral islands of the Pacific and reef-bound shores of New Holland and Australia. We have found many objects of absorbing interest, though, contrary to the usual custom, confining ourselves to the minute forms of life and matter which combine to build up their greatness. But now we must come back to our vulgar drop of stagnant water, which is far from being exhausted of its rich treasures, there being many beautiful things within its compass still awaiting our examination. It may seem a great letting down-a passing from the sublime to the ridiculous-to turn from the marvels of the mighty ocean to the insignificance of a drop of ditch water, but we must remember that our astonishment has been excited, not

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by the sublimity of magnitude, but by the profusion and minuteness of the small. In this view, insignificance becomes the synonym of greatness—little things, but great wonders! In this sense our homely drop of water outrivals the marvelous revelations of the great deep. We should look for great wonders in its boundless waters, and therefore should not be astonished when we found them, but when they meet us so unexpectedly in the drop we are hardly able to comprehend the fact. Narrow as its bounds are, should we aim to exhaust its hidden treasures, it would require many more days of earnest application.

"In returning to its inspection, it is with no intention of describing all it comprehends, but only such forms of living creatures and strange plant-growths as have been so often before our eyes during our past examinations as to excite your desire to know more about them. Even to do this will employ several afternoons yet—more, I fear, than you will be disposed to devote to the subject without becoming weary.

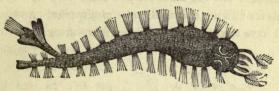
"We will begin with a class of creatures not quite so attractive to the eye as those we have been considering, yet having many points of great interest the *Annelida*, or *worms*. In examining these objects we shall not be very careful to observe the strict family relations, but take them very much as they shall appear under our instruments—worms, molluscs, and insects.

"First let us notice a very queer creature which is perceptible to the unaided eye, and which has often kept up such a 'wiggling' in the water that we have had to remove him in order to continue our observation."

"Oh! here is one now, Mr. Willard," said Tim Allen, "in the drop I'm looking at, and he makes such a fuss I can't see anything."

"Well, Master Tim, pick him out, and see if you can tell me what it is."

"Why, yes, teacher; it is a wiggler, isn't it?"



Larva of the Musquito.

"That is the name commonly given to it, but what is a wiggler? He looks very fierce, with his branching horns and bristling sides, and what queer eyes stare at you! This terrible fellow, children, is the larva of the musquito, so you see his looks do not belie his nature, for he turns into a blood-thirsty wretch. Look into a barrel full of rain

water, and you will see multitudes of them moving about, or hanging with the head downward, with that little feathery tuft at the tail spread out on the surface of the water.

"If you will hold the water between the eye and a strong light, and look very carefully, you may perceive a number of pale thread-like objects moving through the element with wriggling or jerking motions. These are generally some form of the Annelida, or minute water worms, but they are so attenuated that we must put them under the glass to determine their structure. We have had many familiar species under our instruments since we commenced our examination, and some very rare and, so far as I am informed, quite new species. At least I have never seen them pictured nor described.



Vinegar Eels.

"Of the familiar examples is the Vinegar eel: as seen by the power we are using, it is a smooth silvery body, tapering to both ends, and

moves through the water by a wriggling motion. It abounds in stale vinegar, sour paste, and nearly all stagnant water.

"Here is another still more lengthy denizen,

which has often arrested our eye in more than one form, and although not strictly belonging to the class of annelida, yet coming to us in the form of a worm, we will let him pass as a cousin to the family this time. He is named the *Monocystis lumbricorum*.



He is very flexible, and is often seen rolled up into a ball or sharp oval, and by some is supposed to be connected with the production of a distinct class of animalcules, which will come under our inspection hereafter.

"But here is a very marked specimen of minute worms which I have never seen described. It has often been under our glass, and is very common in



the meadow ditches of South New Jersey. It is

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long, slim, with short articulated joints, and very flexible. It has two very bright black eye-spots, with fine dots extending the entire length of the body, on both sides of the alimentary canal, ending at the tail, which is tipped with hairy appendages extending in a circle. As you notice, he is very active, probing into every bunch of algæ or other clusters of matter with evident greediness. In color he is nearly white, or slightly tinged with grayish blue.

"Another interesting object, which has often appeared during our examinations, is also 'unpictured and unsung,' so far as I know, but we will give him a chance for immortality. He is not likely a member of the annelida, although often stretched out like a worm. His general shape is that which we now see—a broad, square nose, with two dark eye-



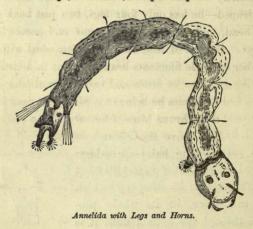
spots, the body then swelling to the middle and tapering by slower degrees to the tail. The stomach is very capacious, through which the contents are seen in a dark, reddish-brown mass, nearly filling up the centre of the body. The mouth is underneath, and is surrounded by cilia, by the use of which it not only feeds, but moves through the water with great speed. This circumstance would indicate its relation to the rotifers in some stage of progress.

"Differing entirely from this, except in the form of the head, is that active monster, with a long, flexible body, many-jointed and hairy. How he wriggles, contracts, and stretches out, as if he would never reach the end of his flexibility! Unless our power is low we can never have him all under the eye at once. He seems also to possess the tenacity of life given to the polyps, as I have often cut one in two-a circumstance which he did not seem to mind, as both parts kept right on with unabated activity. Watch, and see what huge mouthfuls he takes up, which you can trace in its whole progress through the animal until it is finally ejected. The color of the one



before us is reddish brown, although I have seen them nearly colorless, or tinged with green, owing, no doubt, to the nature of the food used. I have observed a peculiar habit of this annelida—the passage of two currents of water into the apertures on each side of the tail, which seem to pass up near the head, where they enter the alimentary canal, and then turn their course, and are ejected with the other contents of the stomach. If this be the fact—and I have verified it again and again—it is a wonderful provision of Nature.

"But here is the leviathan of our minute ocean! A nondescript, a worm, a quadruped! You can



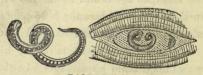
barely distinguish him with the eye as a whitish filament, but under our instruments what a monster! His head is a hard shell, with two staring eyes and a pair of long, straight horns. The mouth is armed with a pair of sharp and strong mandibles, with which he tears his way through every obstruction, and woe be to any poor animalcule that comes within their sweep! I have repeatedly seen a rotifer or a paramecium impaled on one of those terrible jaws. The head seems fixed to the body by a socket-joint, and is often turned at a right angle with the body.

"Many of the annelida have legs, like a caterpillar, at the articulations of the body, but the marked peculiarity of this hideous fellow is that he is a quadruped-he has only four legs, two just back of the head, and two at the extreme end somewhat longer. Instead of feet, each leg is furnished with a number of little filaments branching out in a circle. Resting on these, he bends and twists into all shapes, and when he moves he brings the hind pair near the head, and then throws himself forward with a sudden spring. Just above the insertion of the hind legs there are two long, hairy appendages, like those seen on some species of caterpillars. He is indeed a savage-looking creature, but has always a peculiar charm for me, and I seldom get tired of watching his movements. Like the others which I have mentioned, I have seen no pictured representation of him, nor any description. He is not so common as others, but I have one place where I can always

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find specimens in the summer season—a little bed of chara growing in a clear rivulet just as it emerges from the low arch of a stone bridge. The head only is encased in a shell, the body being soft and flexible. The specimen we have is a very large one, they generally being much smaller—so minute, sometimes, as to be entirely unobservable with the natural eye. I think you will regard this strange creature as a greater wonder than the alligator and big serpents of the menagerie.

"There is a worm belonging to another class, called *Entozoa*, from being a parasite—that is, living in other animals—which we must name because of its fatal effects—the *Trichina spiralis*. It lives and breeds in the muscular fibre of different animals,



Trichina Spiralis.

especially the swine, and by the use of pork it is often introduced with fatal results into the human system. In Germany and some of the Western States whole families have died from this cause. It is exceedingly minute, thousands upon thousands being often found in a square inch of the diseased muscle. If pork or ham is eaten at all, it should be well cooked, as being the only safeguard against their introduction. In the little drawing which I have obtained, the animal is seen coiled up in the section of muscle, and also one separated, both of which are repulsive enough to cause us to guard well against a more intimate acquaintance.

"There are many other specimens of annelida which might be named, but as they have not been under our glasses, we will let them pass.

"The annelida propagate by division, gemmation, and eggs, but do not multiply as rapidly as many other of the minute orders.

"We have had a number of another family of

animals under our instruments which we must briefly notice: the learned call them *Entomostraca*, an order of mollusc with a mixture of the insect. Of



Condona Hispida.

this class is the Condona hispida, or 'Hairy Crawler.' The animal is enclosed in a bivalve with four protruding legs, which are constantly in motion, except when drawn in. In front are two long horns with hairy terminations, and the whole body bristles all over with sharp spines or hairs. A still more interesting object is the little Cypris, a bluish, egg-shaped creature, though often brown and greenish. He has

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the shell and features of the crawler, but is pos-



sessed of great interest as being one of the earliest objects met with in a fossil state. It is very numerous now in the living state, but must have been much more pro-

lific, as its countless remains form strata several hundred feet deep, as seen in Auvergne in France. The Hastings sand and Purbeck limestone of England, more than a thousand feet in thickness, are also crowded with them. Thus, as we look at these little creatures jerking and tumbling in the drops of water before us, we are carried back, in tracing their descent, to unnumbered ages, and like the coral polyps, find in this frail creature another of God's wonderful world-builders.

"The Canthocamptus and Polyphemus are near akin. The first named is of a bright pink, with



Canthocamptus.

Polyphemus.

red spots, and is often met with in all stagnant ponds, where it skips about and breeds with great rapidity.

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"The longer object just beneath these is the well-known Branchiopus stagnatis, abounding, as his name



indicates, in all still waters. He is a singular creature, having a large head somewhat resembling a grasshopper, with a body that seems a skeleton, with the backbone greatly prolonged. The little green animal, with two long feelers at the head and

a pair of ears behind, is the *Cyclops*. He abounds in nearly all waters, and is a very interesting object to watch. His motions are spasmodic, giving a few strokes with his paddles, and then resting, as though looking ahead for dangers before rushing on



too fast. Perhaps in this some of us would do well to copy his example.

"The Alteutha is quite similar.

"But you ask what are those four beautiful red bead-like clusters set in bright green. They are a rare sight, truly: they are the eggs of the little

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Cypris which we have just examined. Each cluster is composed of a mass of eggs glued to a green leaf





Eggs of Cypris.

of duck weed, and thus set, they rival the splendors of the rarest jewelry.

"We have time to notice but one more of the interesting creatures which have come under our eyes this afternoon—the Daphnia, or Water Flea. Like



his namesake on dry land, he has been seen many times during our examination leaping across the field of vision, as though determined to attract our notice. and we will therefore gratify his ambition. He, like the Cypris, is enclosed in a prettily-marked shell, but is peculiar from having two long arms pushing out

just back of the head, which branch into two parts at about half their length, and end with hairy tufts. Just back of the arm-sockets the heart is seen in full action, showing it to possess a very high organization. There are many varieties of this little creature, but all so nearly alike as to require no separate description.

"We have occasionally met with some strange

animals during our examination that have always arrested your attention because they are among the few animalcules gifted with legs and claws: they are the Tardigrada, or Water Bears. We have two varieties before us, differing mainly in the formation of the hind feet, as can be easily observed. They are very curious creatures, and bear no small resemblance to their namesakes as they crawl and tumble among the clusters of algæ to which they always cling. There is one marked difference, however-our little friends have a double quantity of legs. Their claws are strikingly like those of the bear, being long, sharp, and curved.

"There is another point of resemblance—their tenacity of life. The





Water Bears.

bear hibernates during the winter, that is, lives without taking food; so the little tardigrada can be dried up for months, but apply warmth and moisture, and they come forth as active as ever. They multiply by larvæ, and but slowly, compared with many other animalcules.

"We have now spent many pleasant hours in our menagerie inspecting the strange animals which it contains, yet quite as many remain unnoticed, but as we have had the more prominent classes under observation, it must suffice for the present. My object has been, not to teach you the details of this department of Natural Science, but to arrest your attention and give you an outline by which you may be guided in your future excursions into these enchanting regions. But more especially have I desired to impress your young hearts with proper and devout conceptions of God and his marvelous works. I think I have not failed. I hope as many of you as possibly can will secure one of the cheap microscopes found in all the stores keeping philosophical instruments, and prosecute your researches. In each order of the animalcules examined, and which you can now readily distinguish, you will find many species which we have not noticed, and even those most carefully examined will present many points of new interest. Leaving you, then, to complete what we have begun, we will pass, in our next interview, to consider the almost equally wonderful minute plant-life found in a drop of water."

Conferboid Slga.

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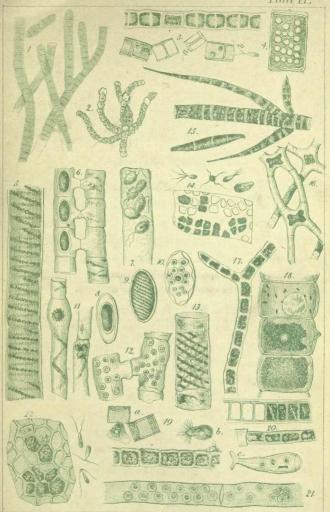
PLATE VI.

CONFERVOID ALGÆ.

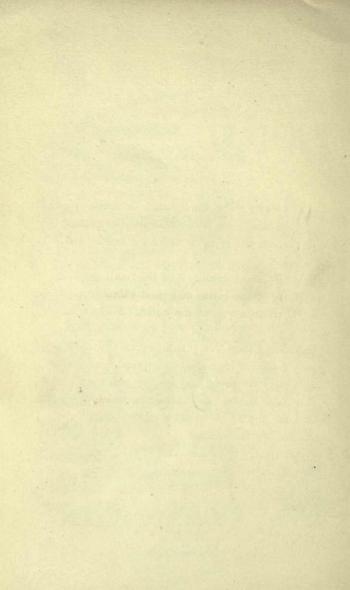
FIGURES

- 1. Oscillatoria autumnalis.
- 2. Nostoc commune.
- 3. Conferva floccosa, with filament breaking up.
- 4. Spirogyra nitida decaying.
- 5. Spirogyra quinina, filament.
- 6. Spirogyra quinina, conjugating.
- 7. Spirogyra cells with biciliated spores.
- 8. Spirogyra spores after conjugating.
- 9. Spirogyra spores before germination.
- 10. Spirogyra spores with globular contents.
- 11. Spirogyra spores with spiny bodies.
- 12. Spirogyra with imperfectly conjugated cells.
- 13. Spirogyra with cell nucleus.
- 14. Monostroma bullosa, with spores.
- 15. Stigeoclonium protensum.
- 16. Staurocarpus gracilis.
- 17. Rhizoclonium obtusangulum.
- 18. Conferva ærea.
- 19. Œdogonium vesicatum, with spores.
- 20. Ulathrix mucosa.
- 21. Sphæroplea annulina.
- 22. Ulva lactuca, with spores.

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Confervoid Algae.



CHAPTER XII.

CONFERVOID ALGÆ.

E are all familiar with the rural picture where sheep and cattle are seen grazing the rich pastures and reposing under the cooling shadea scene that has often inspired the artist to the highest efforts of genius-and the result has been to add some of the rarest and most valuable pictures to the art treasures of the world. Few would suspect, however," said Mr. Willard, "that we can find a counterpart on every slime-covered rock, damp mossy cellar, or ice-house, and spread over the pebbly bottom of spring and brook; yes, even in the 'old oaken bucket' and tumbler in which water has stood for any length of time until a green film has gathered on their inner surfaces. Scrape off some of that spongy substance, as I do from this plate of glass, which has been immersed for a few days in my aquarium, and then put it under the microscope, and we have the green meadow! As with the touch of the magician, the slimy atom is converted into a verdant parterre, with flowers and shrubs and grassy

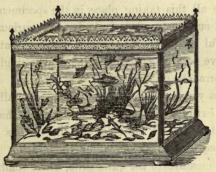
margins of unrivaled beauty, where some of the plants exhibit conditions marvelously akin to animal attributes. Through the tubular centres of some of them, little egg-shaped atoms are seen chasing each other in endless succession, with now and then some tremulous frond breaking up into short filaments or bursting open, out of which pours a troop of these minute spores, with one or more hairy appendages, and at once begin the search for a congenial resting-place. With our highest power we can see all this taking place in the specimens now under our instruments. And what curious and beautiful shapes! Who would suspect that such repulsive screens concealed such surpassingly elegant forms?

"But you may ask, For what purpose do all these things exist? The same divine Goodness that provides the grass of the fields for the ox has made these pastures of Conferva for the grazing of the minute creatures of the water drop, where snails may crop their fill and tadpoles fatten and develop into frogs. Mark that monster Annalid, with his sickle-like jaws, as he mows a wide swath, tearing his way through the thick mass before him. Thus he, with many other compeers, is fed by the same Hand which opens to give us our daily bread.

"But it is in an aquarium that you will see this

gracious provision most perfectly illustrated. Here we can watch the whole process of the plant-growth, and mark its astonishing rapidity of increase, with the manner of feeding by which its richness is appropriated.

"I have a successful aquarium in operation containing about sixteen gallons, which I keep up, not only for its own beauty, but more expressly for the purpose of having ever ready at hand abundant means for microscopic study.



Aquarium.

"To see the objects which it contains, it is necessary to keep the glass clear from the constantly growing conferva, which would soon shut out all observation. It would be very troublesome, and much endanger the arrangement of the larger plants requisite to its vitality, if it were necessary

to scrape the sides of the tank very often. God has most wonderfully provided for this contingency by furnishing a set of industrious scavengers that not only keep the sides of the aquarium clear, but do their benevolent work on a much larger scale in every pond, marsh, and cellar, or wherever the slimy accumulations of conferva are found. Here, amid the rich growth, the whole generation of water snails creep and crop to their fill. Often have I watched the clear pathway which a Lymnea or a Planorbis



Lymnea.



Planorbis.

has made up the sides of the aquarium, and then have seen it drop suddenly to the bottom and start again on its cleansing pathway. Not only do they eat up the too abundant plant-growth of the water, but also prey upon the dead vegetable matter and

decaying animal remains, and thus are co-workers with many species of animalcules in keeping down the death-breeding accumulations. At low tide their pathway is seen over the rocks made bare, or circling around every old log, and along the slimy bottom of the stream, where they are always seen making their slow way toward the water.

"But there is another faithful worker in this sanitary department of nature which must not be overlooked. Here he is in this jar of water taken from the pond back of our school-house, where, sum-

mer and winter, I find a good supply for my aquarium. A Polliwog! Yes, boys, a 'Polliwog,' or, to dignify him with his proper title, which he deserves for his usefulness, a Tadpole. Like the snail, this embryo frog will climb up and down the glass sides of the aquarium, and over the rock-work at the bottom, nibbling off the green covering with an evident relish,



leaving it quite clean. In this state it passes the first summer of its existence, making quite a large increase in size, but no change in form. In the fol-

lowing spring, however, two little legs will begin to push out just at the root of the tail, which appendage commences at the same time to grow smaller. Soon the fore legs make their appearance, and thus it continues to grow—the tail growing shorter as the legs become longer, until none of the former is left, and then look out! To celebrate his deliverance from tails and initiation into frogdom he makes his first ereals faintly at first, as if foorful



his first croak, faintly at first, as if fearful of prema-

ture exultation, but getting courage with each attempt, he climbs to the top of the tank, perching himself on the brink, and panting, as if taking in with a peculiar relish his first inspirations of pure



air. While thus seated he keeps up a sly winking, as though he had just found the secret of escaping from close imprisonment, and then, perhaps, with a loud croak, he makes a mighty leap through the open windows, to seek a congenial home in the neighboring pond to croak among

his fellows. In this very manner I had one escape that I had carefully watched for more than ten months. I thought him quite ungrateful for all the attention I had lavished upon him.

"He is a wonderful and useful little creature, and as he does no harm, I hope none of my pupils will ever engage in the cruel sport of stoning the poor frogs, nor in gathering up whole handfuls of tadpoles to scatter on the dry ground, as I have seen cruel boys do. As they are not amphibious until they have passed out of the tadpole state, they die in a very short time when taken from the water.

"To a certain extent, plant-growth purifies water,

rendering it fit to sustain animal life by impregnating it with oxygen. On this principle the aquarium is constructed, which is but a miniature world. Animals must have oxygen or vital air to breathe. This, growing plants are constantly giving off-a process beautifully seen, whenever a sunbeam penetrates the water, in little pearl drops that gather on the leaves of the plants and go sparkling to the surface. When oxygen is inhaled by animals, carbonic-acid gas is formed and exhaled as a poisonous compound. Unless neutralized by some counteracting process, this would soon accumulate in such excess by the number breathing it as to be fatal, as was once seen in the celebrated 'Black Hole' in Calcutta, where hundreds of prisoners perished in a single night. Now, this poisonous element is just what plants breathe, appropriating the carbon to build up their textures and returning the oxygen to the air purified and ready for the use of animal life again. What a wonderful provision! It illustrates the saying of the Scriptures, that in his hands our breath is, for God has only to destroy vegetable growth, and man would perish from off the earth.

"Now, the secret of the aquarium is to find this balance of plant and animal life, so that one shall nourish and vitalize the other; but how graciously is the balance on our side! We feed the plant with

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poison, while it returns the office by depriving our gift of its venom, and giving it back to us as the very element of our existence! By this beautiful provision, when the happy medium is found, fish and plants remain healthy for months without any change of water. My custom is to renew the water every spring and fall—not that it is absolutely requisite to preserve my pets, but it enables me to wash the rock work and gravel, giving my tank a more cleanly appearance, as the white gravel and small shells are freed from their dark and slimy covering. Two well-kept aquaria, one of salt and the other of fresh water, are among the richest treasures of the microscopist, furnishing him with ample materials for examination when winter has closed the usual sources of supply. But let us return to our little scavengers.

"The growth and multiplication of conferva are so rapid that, unless checked in some way, the rank vegetable matter would choke up all our springs and streams, and even our large lakes. I remember seeing a canal in Ohio so completely filled up in this way that it was very difficult of navigation, and large sums were spent to free it of this obstruction. In this instance there was not the proper balance of animal life to consume the overplus of growth.

"But generally no sooner does the young plant start to grow than the numerous and hungry animalcules, with the whole generation of water snails, begin to crop these submerged pastures, while the annual troop of tadpoles greedily aid them in subduing the rank luxuriance. Nor do these sanitary labors end with keeping back the overgrowth. When the plants have spent their vitality, and decay begins its work of resolving the elements of their structure, our little friends prevent the fatal influences which the slow process might exert with its miasmic exhalations by devouring the putridity, and thus rendering these elements immediately fit for the appropriation of a new race of plants. Let us bless God for snails and tadpoles!

"During our examination we have constantly had under our glasses various forms of conferva. You distinguish them as green fronds and branching clusters, intermixed with egg-shaped and ciliated spores, many of them having a wavy or oscillating motion, while the free spores are chasing each other through the tubular fronds, or strangely swimming about with all the appearance of true animalcules.

"The species are too numerous to be particularized, or even named, hence the list which we shall designate (Plate VI.) contains only a few of the more characteristic, and of these only a part can receive even

a brief description. There will be enough, however, to enable you to distinguish the class from other forms nearly identical which will come under our notice before our examinations are closed. The color is almost uniformly a pale green, varied to darker or lighter shades as they pass from one stage of growth to another.

"The Oscillatoria (Plate VI., Fig. 1) is a very remarkable member of this family, because of the singular wavy motion which it exhibits, and from which its name is derived. It is, as you perceive, a cylindrical filament, divided into short sections by faintly-marked rings, becoming more and more striated as the plants advance in age. After a proper time they easily break into short fronds, from which the active spores escape to complete the work of reproduction.

"The peculiar motion noticed in this plant has arrested the careful attention of all observers, but though more than a century has been devoted to the investigation, the phenomenon remains without a satisfactory explanation.

"Observe the ends of the filaments, and you will perceive a motion much like that of certain caterpillars, when, with half-raised bodies, they sway to and fro, or saw up and down with a slow motion. At other times the movement is similar to that of a

balance, each end going up and down alternately, often accompanied with a slow progress in the direction of one of the ends. With these interesting facts, it is not surprising that some observers have insisted on the animal claims of the oscillatoria.

"The Spirogyra quinina (Plate VI., Figs. 5–12) is another exceedingly interesting minute plant, from the variety and beauty of the transitions through which it passes—now a crystal wand encircled with an emerald wreath; a piece of delicate lace work or string of brilliants; beads of oval form, striped or dotted with green rosettes, with here and there a crystal tube filled with active little spores seeking some avenue to freedom. The plant is a rare one, and the phenomenon of its growth is more easily observed than most of the species. Hence it has always been a favorite with the microscopist.

"In Monostroma and Ulva (Plate VI., Figs. 14 and 22) the escaped spores may be seen, with one or more cilia, moving through the water very much like some of the monads which we have had under notice, with which they were formerly classed by some early writers. And they certainly do bring the animal and vegetable worlds into very intimate relations, when the closest observers are scarcely able to tell just where the line of separation runs.

"In all boggy meadows and shallow brooks the

Staurocarpus (Plate VI., Fig. 16) is found in great abundance, easily distinguished by its graceful quadrate spores, found in the cross branches produced in the process of conjugation, constituting a beautiful net-work of silver and green, sometimes spreading over all the surrounding objects or hanging in fringes in the water.

"The last example which we shall particularize is the one seen in three phases of its growth at the lower right hand of our collection—the Edogonium. (Plate VI., Fig. 19.) There are several varieties of this plant, some of which are the first to make their appearance in the aquarium, and are most common in our ponds. They may be readily distinguished by the dense and uniform green nuclei which they present, with very faint lines between. After a time these break up, as at a, and the spores escape, possessing an unusual number of cilia, as seen at b, while farther at the right, c, the spore is noticed enlarged, developing into new filaments.

"When your attention was first drawn to these tangled masses of green slime," continued Mr. Willard, "you probably concluded that there was little to incite to careful research among such unpromising materials, in which conclusion, I trust, this investigation has proved you wrong, and that hereafter these slimy deposits of the ponds, which boys generally

designate by the rather repulsive name of 'frog spittle,' will have a new and not unattractive interest. You may also learn a very important lesson—that sometimes the most repulsive exterior may hide qualities of the greatest excellence. This the study of the modest conferva has taught us. Few would suspect, when looking at the slimy, tangled mass of fronds in the bog or pond, that God had arrayed them in the beauty which we have just been observing. Nor should we have found this out if we had been repelled by its loathsome exterior. Our care and patience have been rewarded, and henceforth we can see a beauty where uninstructed eyes will look with loathing. To obtain such knowledge is a blessed reward for our pains.

"The practical lesson, my dear children, which may be derived from this example of too hasty judgment, is that we must exercise the same carefulness in forming our opinion of character. Often great wrong has been done in judgment and treatment by premature conclusions. 'Man looketh on the outward appearance, but the Lord looketh on the heart,' is a saying which should always be remembered, and, as far as possible, be our rule of judgment. By so doing we shall avoid many a painful event which would otherwise be a sting rankling all the days of our life. There may be a tender and sensitive nature be-

neath the roughest exterior, and to give a new pang through want of proper observation is more than a mistake—it is a crime. To offend one such is to insult God, according to the teaching of the 'meek and lowly One,' who in this very appellation has constituted himself the guardian of the poor and humble. I remember a fact illustrating this truth.

"I attended in my early boyhood a country school. The house was built of logs plastered with mud, having a broad fire-place at one end. The benches were made from split logs, with round sticks for legs, without backs or arms. Here most of the neighboring boys received three months' schooling during the winter, which, in most cases, constituted all the educational advantages enjoyed.

"Among the number gathered in this unpromising institution was a 'bound boy' from the county workhouse. He was unusually clumsy and uncouth, and soon became the butt of all the school, and the subject of innumerable practical jokes, some of an unusually painful character, all of which he bore with such patience as to lead to the conclusion that he was not only a boor, but a coward also. He never rudely resented the ill-treatment, nor complained to the master, who was himself one of the sterner mood, and seemed to entertain the common impression of the poor 'bound boy.' Though not directly engaged

in the sport of teasing 'Clumsy Joe'—the name by which he was usually called—the fact that I sometimes laughed at his clumsiness or the rude tricks played upon him is a painful recollection to this day.

"Some few of the scholars could see beneath the rough exterior, and were impressed with the fact that Joe had a noble nature which was struggling up into a higher life, that nature strengthened by a spiritual apprehension of that great truth—that the 'fear of the Lord is the beginning of wisdom.' He loved the blessed Saviour, and had caught something of his meekness of spirit.

"That you may the more readily remember the beautiful example of this rough hero, I have put it into ballad form, and will close this interview by repeating it:

"CLUMSY JOE.

"The school-house stood upon the green
Just where the roads were crossing;
And, hidden by an alder screen,
A little brook was tossing.

"'Twas built of logs of river ash,
With clay-beplastered chinking,
And, set within the rustic sash,
Four dusty panes were blinking.

"A jambless hearth there was, and broad,
With hickory logs a-glowing,
Where frosty hands and feet were thawed
When wintry winds were blowing.

- "Its door on wooden hinges hung,
 With latch-string strong and ample;
 Such was the gate we daily swung
 To enter wisdom's temple.
- "Its seats arranged with little care,
 Which fathers, most discerning,
 Designed should teach one lesson there—
 How hard the seat of learning.
- "One prize there was, exciting all
 Ambitious lads and lasses—
 The peerless seats against the wall
 Where sat the writing classes.
- "The pedagogue upon whose skill
 Our learning hung dependent
 Was of the patronymic Crane
 A lineal descendant.
- "Capacious mouth and ample nose, With limbs of sharpest angle, Encased in nondescriptive clothes That loosely round him dangle.
- "Before the glowing fire he sat,
 And trained his callow urchins;
 Who, though they little wisdom gat,
 Yet surely gat the birchens.
- "We gathered here, a double score,
 From every social station,
 That he might train with fostering care
 The dawning inclination.

- "But many a poor and struggling wight,
 With tattered clothes, and mended,
 Found wisdom's ways were not so bright
 When he their steps attended.
- "And such was Joe, a clumsy lad
 Whom no one loved or heeded,
 Whose kindly heart was ever glad
 To do a chore when needed.
- "Encouraged thus, tormenting Joe
 Was thought to be amusing,
 With many a cruel kick and blow,
 And other rough abusing.
- "But though uncouth and overgrown,
 His letters scarcely knowing,
 He meekly bore their jeering tone,
 No signs of anger showing.
- "For he had learned what Jesus said,
 When blows and scoffs are given:
 'Rejoice, and be exceeding glad,
 There's great reward in heaven.'
- "The chief of all that cruel band So sorely once offended, The master took the rod in hand, His utmost arm extended,
- "One scathing blow had stung with pain That made the victim quiver, And high the rod was raised again, Another to deliver,

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- "When Joe stepped out and bravely said,
 While off his jacket stripping:
 'On me let every stroke be laid;
 I'll freely take his whipping.'
- "The master's rod fell by his side
 Before such brave appealing,
 While down his cheeks the tear drops glide,
 Eluding all concealing.
- "The wondering school is thrilled with joy
 That moistened every vision,
 While there he stood, the noble boy,
 So lately their derision!
- "And he whose back escaped the smart
 By such sublime atoning
 Confessed his base, unmanly part,
 His wickedness disowning.
- "No more is heard of 'Clumsy Joe':
 Beneath the outward seeing
 They saw his nobler nature glow,
 Exalting all his being.
- "In all the wealth that man bestows
 Their share was still the greater;
 They yet might wear the finer clothes,
 But he the finer nature!
- "For every scholar owned that day
 That Joe had passed above him,
 And from that hour each one could say,
 'Dear lad! how much I love him!"

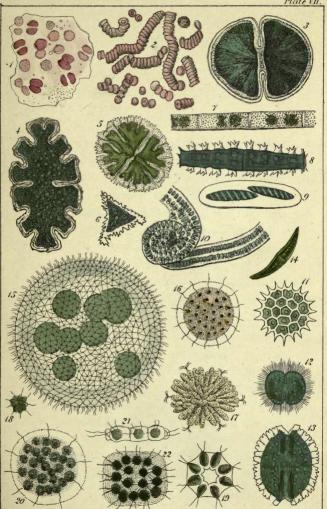
Palmella, Desmids, and Polbocines.

PLATE VII.

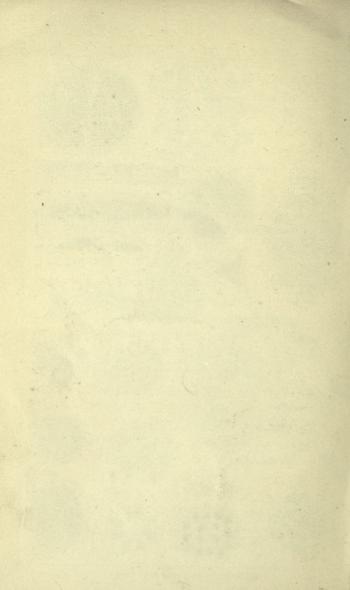
PALMELLA, DESMIDS, AND VOLVOCINES.

FIGURES

- 1. Palmella cruenta.
- 2. Human blood disks.
- 3-13. Desmids.
 - 14. Closteria.
 - 15. Volvox Globater.
 - 16. Eudorina elegans.
 - 17. Synura uvella.
- 18, 19. Protococcus viridis.20. Pandorina morum.
- 21, 22. Gonium pectorale.



Palmella Desmids and Volvocina.



CHAPTER XIII.

PALMELLA, DESMIDS, AND VOLVOCINES.

ONE immediate effect of the lecture on algae was the extemporization of many a rude aquarium by the children until better requisites could be obtained. Pickle jars and large bottles with the necks broken off were used, and happy indeed was the child who secured by parental favor a large glass globe made expressly for this purpose. Ditches and ponds were searched for sprigs of hornwort, chara, and duck weed; snails and tadpoles, minnows, and dace were captured, and, with the addition of a gold fish, some of these little tanks presented quite an attractive appearance. Too many, however, from overstocking their jars, had the sad spectacle of dead fish and decaying plants to punish them for their greediness—a vice which generally carries its own punishment.

At the close of the morning session on the following day, Mr. Willard requested the boys to obtain a jar or two of water from Mr. George's meadow, where there was a shallow ditch running through overhanging rushes, and filled with watercress. The water was quite clear, having its surface covered with oxygen bubbles when the sunshine was hot upon it.

This commission was a delight to the children, and when school adjourned half of them rushed to the neighboring meadow to obtain the desired specimens. In searching for the clearest spot to dip up the water they came to an old stump, whose roots spread out in long bare arms, now dipping in and rising out of the water, and covered with slime. But the children were almost horrified to notice that there were great patches of blood here and there all over them. They supposed at first that some animal had been slaughtered there, but the more observing felt sure that such a proceeding would not leave the blood scattered in such separate patches, and as they could not understand the matter, they determined to take some of it to Mr. Willard, who, they doubted not, would be able to give them a satisfactory explanation of the mystery.

When assembled in the afternoon for the usual interview, George Snow presented to the teacher the jars of water which he had requested, and told the discovery which they had made.

"Oh, Mr. Willard," said he, "we found an old stump standing partly in the ditch, with its roots all covered with blood, and we've brought some of it for you to look at. We couldn't tell how it got there."

The teacher looked at the gelatinous mass for a few moments, and then replied:

"Ah, boys, wiser and older ones than you have been unable to tell what this bloody mass is, or how it was scattered so profusely around. Let me give you an incident found in Dr. d'Aubigné's History of the Reformation, in which you will see that very learned men were made to tremble with fear before such a spectacle. He writes: 'On the 26th of July, a widow, chancing to be alone before her house in the village of Castelenschloss, suddenly beheld a frightful spectacle-blood springing from the earth all around her! She rushed in alarm into the cottage. . . . But oh, horrible! blood is flowing everywhere; from the wainscot and from the stones; it falls in a stream from a basin on the shelf, and even the child's cradle overflows with it. The woman imagines that the invisible hand of the assassin has been at work, and rushes in distraction out of doors, crying, Murder, murder! The villagers and the monks of the neighboring convent assemble at the cry; they succeed in partly effacing the bloody stains; but a little later in the day, the other inhabitants of the house, sitting down in terror to eat their evening meal under the projecting eaves, suddenly discover

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blood bubbling up in a pond—blood flowing from the loft—blood covering all the walls of the house. Blood—blood—everywhere blood! The bailiff of Schenkenberg and the pastor of Dalheim arrive, inquire into the matter, and immediately report to the lords of Berne and to Zwingle.'

"Now, if this had really been blood, it would have been a sufficient cause for all this excitement and terror. But there was no blood about it, which could easily have been found out had these men been familiar with the use of one of these wonderful instruments. The substance which produced all this alarm was doubtless the same as that which has excited your imagination, and there is no blood about it, although to the unassisted eye it has the exact appearance of this fluid in a coagulated state. It is, however, a well-known species of confervoid algæ called Palmella cruenta. (Plate VII., Fig. 1.) It is very common on damp walls and other shaded places, and under favorable circumstances develops with astonishing rapidity. It was doubtless such a combination of circumstances favorable to its production that caused the event so horrifying to the Swiss villagers, allowing some considerable latitude for their over-excited condition and tendency to superstition. It appears at first in rose-tinted gelatinous patches, which at times spread with such rapidity as to become confluent, and would, with the help of a heavy dew or slight mist, form little drippings from the eaves and walls. It is likely that this was the full extent of the phenomenon seen by the frightened woman; the story of the cradle dripping with gore was either imaginary or caused by a few stains made by drops from the ceiling above.

"Some writers have supposed that the miracle of the waters of Egypt turned into blood was produced in this way, aided, perhaps, by the euglena and astasia, which have already been noticed. Most of those terrible plagues were but natural agencies used in a supernatural way, and he who can discolor the sea by similar invisible atoms could cause the crimson palmella to redden the Nile and other streams of Egypt in a single night. It requires but a brief time for them to lose their bloody hues, when they decay and fall to the bottom, enriching the soil which they had reddened with their dyes.

"The celebrated 'red snow' of the Arctic regions is now generally attributed to the same curious little plant. Captain Ross, in his voyage, states that he found miles of this red snow, extending to the tops of high mountains and buried many feet beneath the surface of the ordinary snow. How wonderful! Its roots can feed on eternal frost, as well as cleave to the sun-warmed surface of milder regions.

"I have said that the microscope takes away all the bloody terrors which this substance has so often excited. We can soon demonstrate this by putting the two things under its powers. The palmella thus inspected appears a homogeneous jelly, in which are embedded minute globular cells of a beautiful rose color of darker or lighter shades. These gelatinous patches are single, or run into each other without any uniformity of order. Now let me change your stump blood for some taken from my own veins. A prick with the point of my knife will produce enough for all our instruments.

"There! a single look will show you the radical difference. We have now long rows of half-tilted circular disks, or, as they are generally called, blood corpuscles. They have the appearance of a pile of five-cent pieces toppled over, but not entirely separated. Separate one of these disks and turn it down, and there will be seen a slight depression in the centre. The blood disks of the mammalia are circular and concave, while those of fishes, birds, and reptiles are elliptical, with flat or convex surfaces.

"The human blood (Plate VII., Fig. 2) is not, as you suppose, of a red color, any more than the waters of the ocean are red or green when they have this appearance by the infusion of millions of aninalcules. Take away the infusion, and the natural

color of the water will be restored. So with the blood, the fluid of which is of a pale yellow tint, and it is the infusion of millions of little red corpuscles that gives it its sanguine color. These minute atoms, as we are told by M. Bouillet, a French philosopher, measure not more than the three-thousandth part of an inch in diameter, and there are more than a million in such a drop of blood as would hang on the point of a needle. This coloring matter of the blood is called hematine.

"These conditions of the blood put a meaning of profound interest in the declaration of the almighty One when he said to Cain: 'The voice of thy brother's blood crieth unto me from the ground.' The microscope has enabled the blood thus to speak with a sure testimony against those who dare wickedly to shed it, and also to tell the very part of the body from which it was taken, as the following incidents will most strikingly illustrate:

"Some years ago a man was found murdered by a terrible gash across the throat, and a suspected individual arrested, the most suspicious circumstance being a knife found in his possession having a number of dark stains upon the blade evidently made by blood. He accounted for them by stating that he had cut some raw beef with it, and had omitted to wash it. Now, had he known the facts

which we have learned, he would not have made a statement so fatal to his cause. The knife was examined by an expert microscopist, who fixed the bloody nature of the stain. At the same time he detected the falsehood of the prisoner's statement that they were made from raw beef, for they were produced by the blood of a living animal. The drippings of dead flesh are watery, the blood being dissolved into serum, while living blood coagulates very soon after being exposed to the air. This was judged to be coagulated blood. The blood was probably human blood, for it had the clearly-defined blood disks of the size and shape found in human veins. It was found mixed with cotton fibres exactly corresponding with the neck-handkerchief of the murdered man. And more fatal still was the existence of certain little cells of a tesselated form which are only found in the tissues of the throat and bladder. Thus step by step the fatal evidence was given by this wonderful witness, which sent the man to the gallows for his crime. His brother's blood cried from the blade of the assassin's knife, and the microscope gave it a voice to bring vengeance on him who used the steel for the ruthless deed.

"But there was a case of equal interest which occurred in Philadelphia only a few years ago. A man was found murdered and thrown on one of the

vacant squares in the eastern part of the city. In searching after the facts, it was ascertained that he was last seen alive riding in a market wagon with a young man. As this individual had no such vehicle of his own, it was evident that it had been obtained from some stable in the neighborhood, where it was soon traced. In examining the wagon some dark stains like blood spots were found spattered on the sides and bottom. To account for these the young man said he had been carrying some chickens to market. Ah, had he known the searching power of our wonderful optics, he would never have thus exposed his guilt by so fatal an attempt to conceal it.

"God, who knew that just such wicked devices would be resorted to, when he filled the veins of man and fowl with the blood, 'which is the life' of all flesh, ordained that it should not only give life when running therein, but should also testify against those

who should wickedly open those veins to let it out, and so he bent the circumference of that found in the veins of the fowl into an oval, and this fact revealed the wicked lie by which the



Fowl's Blood.

criminal sought to conceal his dreadful crime. The blood was not chicken blood, but came from mammal veins. This was well established, and the murderer went to the gallows.

"Thus, you see, the microscope not only dissipates the dark clouds of superstition, lifting its horrors from the heart of man, but also puts a guard around his life, and points out with fatal certainty the bloody steps of the wary assassin, which it clearly traces out where the naked eye is baffled and gives up the search.

"But we have lingered some time over this subject, though not longer than its deep interest will justify, and must now pass to other objects which are awaiting our examination. In so doing we shall reach a very interesting class of microscopic studies, not only because of their exceeding beauty of shape and color, but from the fact that it has long been discussed among the learned whether they should be included in the animal or vegetable kingdom. Like the shuttle-cock, they have been tossed about between these two factions, now exalted to the dignity of the animal race, only to be the more rudely thrust down again to the green pastures of the algæ which we have just been considering, to serve for food for the order to whose equality they had aspired.

"We will not enter into this war of races, nor stop to discuss the pros and cons. Our purpose is to wonder and enjoy; and be they animal or vegetable, they are very interesting objects for consideration—

peculiarly so from the fact of forming this perplexing link between the two kingdoms. If they are animal, they excite our wonder and admiration by their exceeding delicacy of shape and brilliant colors, but if belonging to the lower vegetable order, they present the striking phenomenon of plant life endowed with an independent existence and instinctive volition, moving at will, feeding, propagating, and doing other things which seem only to belong to the orders endowed with the functions of animal life. Certainly, whatever may be the true state of the case, the two races are brought very near together when they are so blended that it puzzles the most learned to determine the line of division. knowledge of this fact can but enhance the pleasure of our investigation, during which, I have no doubt, you will be involved in the same perplexity which has befallen the learned—now, being sure that what you behold is nothing but a bit of minute algæ; but anon, as you see the object begin to roll or creep before your eyes, you will as positively affirm that it can be nothing less than an animal. So it is more than likely that you will go from the school-room to perpetuate the long-continued discussion, while the little desmid and diatom, volvox and pandorina, will continue their life work, indifferent as to where you place them, it being their vocation to fill the

sphere which God has assigned them in the grand perfections of nature.

"Of this paradoxical class the Desmids will first claim our attention. (Plate VII., Figs. 3-13.) These graceful objects are generally of a bright grass-green color, often combined with the most delicate edgings of the purest crystal filagree work. Long ribbons are seen striped, dotted, and figured, ovals and diamonds in profusion, sceptres and crowns. In looking at a fine grouping of these beautiful forms, such as we now have under our glasses, one can easily imagine himself roaming through some ancient hall where hang the princely shields and helmets of kings and warriors, where gold, diamonds, emeralds, and crystals are displayed in the greatest profusion, interspersed with gold and green silken sashes, marshals' batons, and other insignia of kingly and knightly honors. Certain it is that the reality of such surroundings could present nothing more beautiful than the scene now under our eyes in these six drops of water. We will not bother ourselves with the long, hard names of the different varieties of the order now under our notice, as this general view will enable you to distinguish them from the Diatoms, which we shall examine before we close our entertainment.

"Desmids are plentifully found in all ponds and

brooks, especially liking clear, running water. They often so abound as to cover the bottom of the stream, and are found thickly adhering to water-plants and decaying leaves, so that they are easily found when wanted for examination. They multiply by subdivision and conjugation, and with great rapidity. The subdivision takes place in the direction of the clear lines seen dividing the green sections.

"Perhaps the most attractive of these curious plant-animals is the well-known Volvocine, the Volvox globator (Plate VII., Fig. 15), so called from its shape and peculiar manner of moving through the water. This beautiful organism will illustrate my remark that it is almost impossible to resist the conviction that we are beholding an animal, instinct with life, when we mark its graceful and independent movements. It seems a degradation to class it with the motionless forms around it. It is a minute revolving globe, with a delicate net-work enclosing the body, within which are seen several bright green spots, being the young volvocina preparing for their advent into the watery home. The globe is about one-thirtieth of an inch in diameter. At the intersection of each mesh of the net-work two cilia are attached, by means of which its revolving motion is produced. This motion is very graceful, now forward and backward, up and down, or in a circle,

the green spots producing a very beautiful effect. When these spots arrive at maturity they break from the parent cell and launch forth to try their own fortunes. If all this is done by a mere plant, how wondrously it must be constituted! We have heard of 'climbing fish' and 'live oats,' but a plant gifted with organs of motion and instincts to use them, flying here and there as led by whim, reproducing its young by a bird-like process, is certainly a marvelous illustration of the handiwork of the great Creator. During all the warm months of summer they can be found in places similar to that from which you obtained them to-day.

"Akin to this is the more minute and beautiful Eudorina elegans (Plate VII., Fig. 16), though its family relations are not fully settled by the learned. Its brighter colors give it a rich appearance as it rolls through the water with motions similar to the volvox.

"The Synura uvella, just below this, is composed of many little yellowish oval bodies united at a common centre, and pushing out until they form a globe-shaped cluster, revolving after the usual fashion of the volvocines. The Protococcus (Figs. 18, 19) are of similar habits, but much more numerous.

"But here is the active little Pandorina (Plate

VII., Fig. 20), which deserves a brief notice for its marked peculiarities. You will observe that milky gelatinous mass, beneath which are seen several little green pear-shaped bodies twisting and turning to get free, which they accomplish after a while. This beautiful creature and the Gonium pectorale (Figs. 21, 22) were included by Ehrenberg among the monads, this last being a plate, hence called by him Tablet monads, composed of sixteen green points, which after a while break up into four, and then in turn increase to the same number and again subdivide. As this occurs many times in an hour, we can conceive what incomprehensible numbers must be produced in a few days, and who can estimate the product of years? Their motion is edgewise, when they have the appearance of a long, thin figure. (Fig. 21.)

"These rolling spheres glancing in the light as they move to and fro add very much to the interest and beauty of microscopic examinations. And what a stretch of creative power, from an invisible globe to its sublime compeer circling the immeasurable depths of the starry heavens! Yet the same God is seen in the minuteness of the one and in the incomprehensible magnitude of the other, and man could as easily build up the sublime structures of the skies as fashion the delicate and invisible mote-life of the drop of water.

"By varying the light thrown on the glass illuminator some enchanting transformations are produced while observing these volvocines. A little change, and they are a disk of crystal studded with emeralds, and anon with topaz; then the crystal fades away, and we have a system of beautiful green plants pursuing their mazy dance in perfect harmony and order. The picture is perfectly enchanting, and I have often been held spellbound by its marvelous attractions.

"We must not dismiss our present subject without paying a passing notice to the beautiful family of Closteria. (Plate VII., Fig. 14.) It is easily distinguished by its golden green crescent form, spotted and striped with great delicacy. It is very abundant in all ponds where plants are found growing, and you have only to scrape the leaves of a bit of duck weed to obtain these pretty objects for examination. They multiply by subdivision, the separation taking place just where you see a band dividing the parent in the centre—a process which is constantly going on.

"It has been ascertained by those who have carefully observed the Closteria with a very high power that it is ciliated and possesses the power to move by very slow degrees, and will thus bury itself in the mud if given sufficient time to accomplish the

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feat. On this fact has been based its claims to a place in the animal kingdom.

"But our hour is more than expired, and we must close our interview, reserving the *Diatoms* for our next exhibition."

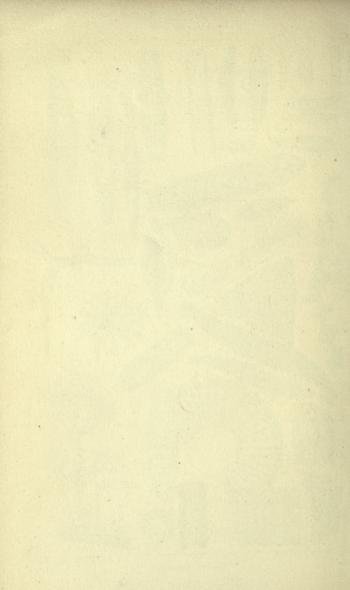
Libing Diatoms.

PLATE VIII.

FORMS OF LIVING DIATOMS.



Living Diatoms.



CHAPTER XIV.

LIVING DIATOMS.

THE children were exceedingly interested in the last exhibition. The beautiful volvocines called forth their highest admiration, little Nettie Newton declaring that they were the prettiest things she had ever seen in her life.

"Just think," said she to her papa, "of a beautiful green and golden globe floating through the air; wouldn't it be splendid? Well, we saw, oh! so many in a drop of water; some were green, and some were red and yellow, and they went rolling about in the funniest manner. I never did see anything so beautiful."

"Why, daughter, not when you looked in the glass?" replied the father, with a quiet smile.

"Now, papa, don't tease me," replied the daughter; "I'm not a globe, or beautiful either."

"That may be, but I very often detect two bright blue globes peeping into the looking-glass," responded the doctor, "and I wonder what they are gazing at so long sometimes, unless at my little Nettie?"

"Why, of course people have to look into the glass sometimes. But, papa," continued Nettie, "Mr. Willard told us how people have been frightened at what they thought was blood running out of the ground, when it wasn't blood, but a little plant; and then he showed us some real blood, and they were not alike at all. He showed us some chickens' blood, and told us how men had been hung because their guilt had been found out by the microscope. It was a good deal nicer than a real made-up story. I just wish you could have heard it."

"Well, well, my daughter," replied the gratified father, "I am glad you have had such a nice time, and have profited so much. I should have enjoyed the occasion very much, I have no doubt, although I have witnessed many such things, and was present on one occasion when a man was convicted of murder by the aid of the microscope."

"But, papa," continued the daughter, "do you think Mr. Willard could tell the difference if the blood of men and chickens were mixed all up together? Some of the boys don't believe he can, and are going to bother him by bringing some to school to-morrow. I hope he can, for I don't want him teased."

"I guess," replied the doctor, "you need borrow no trouble on that score; Mr. Willard will come out all right."

"Oh, I'm so glad," exclaimed Nettie, "for I do love him so much, for he just tries all the time to make us children happy."

As Nettie intimated, some of the boys doubted their teacher's ability to distinguish between the blood of different animals when mixed together, and had determined to put it to the test at their next interview, by producing some blood from their own veins mixed with that of chickens.

Accordingly, when ready the next afternoon, their proposed test was produced, and Mr. Willard was asked to tell to what animal the blood belonged. To this request he cheerfully yielded, not knowing the object which the boys had in view, and even had he understood this it would have made no difference, as it would have furnished him with a good opportunity to teach them a more impressive lesson. As it was, he was only too willing to gratify his dear pupils. Putting the blood under one of the higher powers, he examined it for a few moments with great care, and then said:

"I perceive that some of you have been preparing a test for me. This blood is mixed, being composed of mammal and chicken blood-disks. This would not likely occur except from design. Be this as it may, I am quite ready to give you this new test of the truthfulness of our little brass witness. The human tongue may utter falsehoods, but this witness, never. We may not always be able to interpret its testimony, but it will always be given with the strictest exactness, nor can it ever be bribed or perplexed by cross-examinations."

Little Nettie was in ecstasies at the emphatic triumph of Mr. Willard, nor did the doubters after that cherish any more thoughts of perplexing their teacher. They were well convinced that when he made an assertion he could make it good.

When this little episode was concluded, Mr. Willard introduced the topic of the hour by saying:

"It was stated in our last interview that the diatoms have shared with the desmids in the struggle to preserve a place among the animal races. This they have done with a larger measure of success, as the majority of ablest writers insist on their just claims to this honor, and undoubtedly with a vast preponderance of facts on their side. But as a settlement of this vexed question does not come within the compass of our aims, we will leave it for other persons to adjust, and consider the diatoms as they appear to us; and an interesting study we shall find them, from the peculiar beauty of their shapes, delicate

external markings and bright silicious shells. They appear everywhere, and though the period of their life may be very brief, yet the indestructibleness of their shells gives them a perpetual record; hence the present living races are linked back to the first-born of life. Mammoth and mastodon have passed away, leaving nothing but a few scattered wrecks of their former existence, but the living diatom of to-day moves among the monuments of his departed ancestors, sweeping back to the Deluge and beyond its swelling floods, even before the mountains were upheaved from their watery chambers. We can, therefore, but look upon them with increased wonder; they are not only minute and surpassingly beautiful, but most ancient, tracing their lineage farther back than any other family of earth. They come down to us without a break in their descent, and what they were when Adam lived they appear before us now. No development has changed their forms, nor cast off their beautiful shells for scales or wings, nor given them legs to creep. Darwin would find but poor confirmation of his favorite theory by calling the little diatom to the witness stand.

"The diatom is composed of two symmetrical plates or valves, in some instances, as in the *Navicula*, shaped like a small boat. They are sometimes joined together lengthwise, stretching out like a

long flowing ribbon, from which they break one after another and go creeping slowly away. Other species grow in tree-shaped clusters or loose-jointed branches, with broad fan-shaped leaves. Long chains of square or oblong links, curiously joined at the corners, are scattered about, with golden circles, ovals, diamonds, crescents, stars, sceptres, and little boats mingled together in the same drop of water.

"But whatever may be the outward shapings of these ancient families, they all follow the one great law of disintegration, scattering widely to serve the great purpose of their Creator, who honored them with an existence long before man came from his moulding hand.

"This fact accounts for the vast numbers of these little boat-shaped objects which we see slowly crossing the field of our instruments. When, during their progress, they chance to touch each other, they suddenly slide themselves together, often forming little clusters, as though they were enjoying a few moments' social intercourse. They are the most widely diffused of all forms of infusorial life, living alike in fresh or salt water, in pure streams or dark morass, growing to plants or crawling on the slimy bottom. They are said by some to have the cilia at both ends, and projecting also from four minute

holes in the middle of the shell. These phenomena can be seen only with instruments of very high power and careful watching. They are so numerous as often to impart their color to the aquatic plants to which they are attached, although individually so small as to remain wholly invisible to the unassisted eye; seen, yet not seen, everywhere, yet observed nowhere, except under the microscope.

"This branch of microscopic study is just now exciting renewed and more careful attention, and it is not to be wondered at, for the exceeding beauty of the diatom ever delights the eye, while their universal diffusion, and the important part they serve in building up the natural and artificial monuments of the earth, will ever strike the mind with wonder. So universally spread through all lands, and so ancient, they are designed, no doubt, to work a most important result in the economy of nature. But how long they toiled unknown and unthanked! Yet they ceased not in working out their mission, and when each one had finished its life-work, it left its beautiful shell as a monument to tell of its industry.

"These beautiful objects are found enjoying their brief life in all waters, even the clearest, but most abundant in salt water, especially in all shallow collections left by the tide in salt meadows and pools. From these places they can be taken by millions, possessing the most perfect and beautiful forms. To their presence is mainly owing the yellowish tint which these waters always wear. They can be obtained also in great quantities by scraping the submerged posts and planking of the docks, or the slimy stones in brooks and rivers. Indeed, you will hardly miss them wherever you may seek, for they are always present where moisture is found. From their giving off minute bubbles of oxygen from the little holes seen in the centre of their shells, they often come to the surface of the water and float as a yellowish-brown scum, and will be found in the yeasty accumulation on the shore after a hot day in summer.

"The epicure of oysters may not be aware that with every delicate mouthful he swallows he devours hundreds of these minute molluscs.

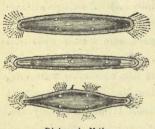
"To show how indestructible the diatoms are, it may be observed that they are found equally in the coldest regions of the North and the hottest of the tropics; they will even pass through the fire, yet retain their perfection of outline, though the life will be extinct, the frustules being pure silica.

"Since the animal, as we have no doubt it is, is constantly undergoing rapid growth and subdivision, it would seem God's great laboratory for the production of this important mineral, considered one of the primitive earths. It is but another instance showing how his creative power works out the greatest results from the smallest beginnings, hidden in the remotest causes. He begins with a diatom the one hundred and thirty thousandth part of an inch in size, and ends—where?

"In Dr. Griffith's Microscopic Dictionary there is a catalogue of one hundred distinct varieties of diatoms, while we have under our instruments only a little above thirty. (Plate X.) A scientific German has taken this list of Dr. Griffith's and performed one of the greatest wonders ever witnessed in scientific manipulation. We must remember that all these forms of diatoms are exceedingly minute, and cannot, therefore, be handled by any instrument but what must be many times larger than they are. Yet this man has placed them in the exact order of their classification, in ranks with as much regularity as soldiers, and all in the space which would be covered by a ten-cent piece!

"How he accomplished this is a wonder, and we need not be surprised that the little glass slide on which they are mounted cost the sum of forty dollars at the shops. The man must be possessed of remarkable skill and patience to have achieved such a marvel of science and mechanism.

"It may seem a little tedious to watch some of these tiny creatures as with slow movements they push across the drop of water, but it will repay those who have the patience to do it. The study will go far to convince any one of the animal nature of the diatom, when it is observed with what promptitude it turns aside from any obstacle which may impede its progress, perhaps with a sudden jerk to the right or left. Dr. Hogg states that he has watched the process attentively, and is fully satis-



Diatoms in Motion.

fied that their motive power is derived from cilia, so arranged at either end and from the little opening in the middle as to act as oars or paddles. This fact, in his opinion, settles their ani-

mal relations. We can plainly observe the movement, though our power is not sufficient to reveal the cilia.

"The diatom possesses a marked interest to the scientific microscopist as a test object.

"It is known that certain species of the diatoms have a specific measurement and peculiar markings which can be seen only by the use of a certain magnifying power. When, therefore, an undefined power is to be fixed, one of these little shells is put under the glass, and its power is readily rated. It requires one hundred and thirty thousand of one species of these little creatures to fill the diameter of an inch, and thirty thousand of the largest.

"Their color varies from the brightest yellow to a dingy brown, but yellow being the predominant shade, they give this tinge to the leaves of plants on which they abound.

"The markings of some varieties are exceedingly beautiful, the body often being of a pearly whiteness, dotted here and there with yellow, red, and green, or traced in elegant scroll work or graceful circles and lace-work edgings. Occasionally one will be seen attached to some sprig of alge by a long staff, with the top spread out like the yellow flag of a military hospital.

"As we disposed of the desmids, in like manner we shall not stop to name and describe each of the hundred diatoms which have been classified, but having presented the class in general outline, leave you to learn their technicalities when you are better prepared to acquire and understand them. From the view given, you will be able to distinguish them from the other curious things met with in future microscopic examinations.

"Here we must close our investigations of the strange forms of life found teeming in the little world of water which we have so long and profitably had before us, although we have scarcely touched its miraculous borders.

"But the things having life are only a tithe of the hidden treasures which can be searched out. The animated atoms that 'people the sunbeam' and swarm in the rain-drop are as nothing compared to the infinite number whose sepulchres are the everlasting hills and the islands of the mighty deep. The dead are everywhere in the rock-ribbed earth. On them the foundations of the mountains are laid. By their accumulation the beetling cliffs are heaped up along the ocean's shore to stay the marching desolation of its restless waves. They filter through the air on the wings of every wind, dropping on the hungry soil to give it fertility; they underlie cities and continents; they are built up into palaces and pyramids; omnipresent on earth, yet individually invisible to the sharpest unaided vision.

"In searching the vast burial-places of the infinitesimal dead, we shall find objects of equal interest to those revealed in the living millions that have moved before us in the drop of water, except in the greatest of all mysteries—life! We can but see their outward shapings and guess at the manner of life which

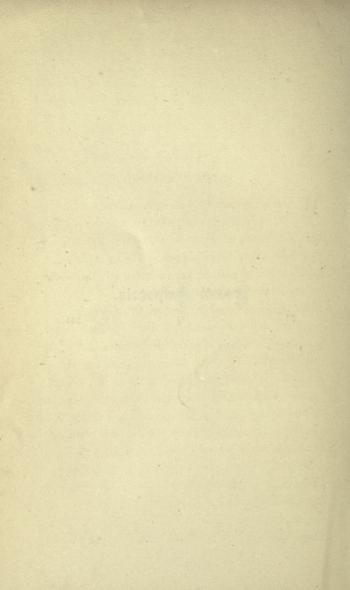
they once enjoyed. The vast earth their death has helped to build up, and in a large degree fitted for the dwelling-place of a higher order of beings who should come after them. In all and through all these wonderful mutations we can trace the same wisdom and power working out the beneficent purposes of God, often most gracious when his vast designs are deepest hidden from our observation-hidden not always behind that which is incomprehensible from its vastness, but concealed by the very minuteness of the agency which he employs. It is often as true in nature as in spiritual things that God chooses 'things that are despised, and things that are not, to bring to naught things that are,' and for the same impressive purpose—'that no flesh should glory in his presence.' We sow our broad acres of grain, but a little fly eats out its life; plant our orchards, and the sting of a minute bug turns our fruit to rottenness; build our houses and barns, and a spark of fire turns them to ashes. Can we fail to comprehend these lessons? 'Thou fool, so is every one who is not rich toward God.' We must see God in everything, and revere him everywhere.

"With him a hair is as omnipotent as a chain of linked worlds. The strength is in neither, but in God, who works through them. He can hide his face and his favor behind that which is most minute,

as well as withdraw the sun from the heavens and shroud all in blackness.

'Deep in unfathomable mines
Of never-failing skill,
He treasures up his vast designs
And works his sovereign will!'"

Fossil Infusoria.



CHAPTER XV.

FOSSIL INFUSORIA.

WHEN the school was again assembled for the coveted hour's enjoyment, it was noticed that the bottles out of which so many wonderful things had been taken had disappeared, being replaced by the little boxes and a large number of glass slides, on which were mounted objects.

Mr. Willard began his lecture by saying:

"You may have wondered why I desired you to procure these boxes of marl, chalk, rotten-stone, and similar substances: this afternoon will explain my purpose. In our examination of the coral polyps we learned what mighty structures they have built up in the ocean, but their dwellings are the result of ages of persevering activity. When dead, they are either absorbed into the mass of their building or dissipated into the elements, leaving no perceptible addition to the superstructures which they were raising. Not so with the Fossil Infusoria, which we are to examine this afternoon. These minute shells, when left tenantless by the death of the inmate,

added with each generation a new layer to the foundation which the sepulchres of their ancestors began, and which, accumulating through thousands and thousands of years by imperceptible degrees, have become gigantic and sublime in their magnitude. It would be a fact beyond belief, were it not demonstrated by unmistakable evidence, that the mighty Andes, rearing their heads above the clouds, towering more than twenty-five thousand feet above the level of the sea, are largely the heaped-up remains of the most minute animalcules—not a valley of dry bones, but a vast mountain of the dead. And not only have they helped to pile up the Andes, but stretched out mighty beds of slate in Austria and Africa, known as tripoli when ground to powder; reared the chalk hills along the coast of England, and laid the foundations of Paris in France, of Richmond and Petersburg, and many other places in our own country. They are built into the pyramids of Egypt and temples of the Nile, whose fertile waters also bear them from the mountains of Central Africa and the desert sands to fertilize its banks at the annual overflow. Nor need we go so far from home to find these populous cities of the dead: the ground on which we tread in coming and going to school is full of them; nor is there likely a spot on the broad face of the earth where the foot can be

placed without resting on millions of the dead. The language of our great moralizing poet is not only beautiful but true:

'The golden sun,
The planets, all the infinite host of heaven,
Are shining on the sad abodes of death
Through the still lapse of ages.

'All that tread
The globe are but a handful to the tribes
That slumber in its bosom. Take the wings
Of morning, and the Barcan desert pierce,
Or lose thyself in the continuous woods
Where rolls the Oregon, and hears no sound
Save its own dashings, yet the dead are there;
And millions in those solitudes, since first
The flight of years began, have laid them down
In their last sleep: the dead reign there alone!'

"If this language can be applied to man's monuments of mortality, how much more so to the thousands of species which mark the descending scale from him to the minute diatom!

"The marl beds of New Jersey are rich with these accumulations, mostly in the form of shells, called Foraminifera. In this yellow specimen of marl obtained by you we can detect many of these shells with the unassisted eye, perfect as those found on the sea shore, in which state, however, they will re-

main but a short time, as they soon slack like lime and crumble to dust. But when we have picked out all that the eye can detect, put the remainder under the glass, and thousands more will be easily found more rare and beautiful. These minute forms are not confined to the dry land, but more largely abound in the ocean. We are told that a cubic inch of the stone from which the tripoli is made weighs two hundred and twenty grains, and contains no less than forty thousand millions of distinct organic forms-minute shells; but in making soundings for the Atlantic telegraph a little sediment was brought up from the bottom of the deep sea, and, when dried, was found to be a dust so fine that when rubbed between the fingers it would disappear in the pores of the skin. Yet on placing this powder under the microscope, this almost impalpable dust was found to be composed of perfect shells, with the little holes through which the tentacles of the extinct rhizopod once protruded. These shells are found in all geological periods as we go down into the strata of the rocks or depths of the sea. Who can help exclaiming, 'O Lord, how wonderful are thy works!'

"In order to see these shells in perfection, the chalk or marl must be washed, and the object mounted, as it is called—that is, placed on one of

these glass slides. I have a number of them thus prepared which I will now place under the instrument for your inspection.



"Like the diatom, the Foraminifera have their living generations linking the present with the remotest past. Of the great beauty of the living race

you have had a glimpse in the minute wonders of the sea. (Plate V., Figs. 1-5.)

"There is an interesting species of these shells called Nummulites, or coin stones, of which the blocks of stone built into the great pyramids of Egypt are mainly composed. The chalk hills of England are particularly rich with these deposits. It was at first believed that chalk and flints were formed by the rushing of heated water largely impregnated with lime and silica into the colder waters of the ocean, and precipitated by chemical affinity. It is shown by our wonderful instruments that this theory is wholly wrong. These substances are of animal origin. Chalk, marl, flints, marble, tripoli, opal, and semi-opal are all found in the same wonderful manner. The fact is astounding, vet most palpable, that a very large, if not the largest, portion of all our sedimentary rocks is formed of animal remains. Tombed and cenotaphed, the earth is the vast cemetery of the minute dead, which we despoil to deck our houses or adorn our persons. The polished marbles on our centretables, beautifully shaded with dot and stripe, owe all their elegance to the skeletons embedded within their substance. Here is a fragment of semi-opal from the great bed of tripoli at Bilin, in Bohemia, less than a half inch in size, a, in which no distinct

organic remains can be distinguished; but let us place it under our glass.

"Now you can see that it is filled with perfect organisms—shells, wheels, animals of strange and



Semi-Opal Magnified; a, original size.

beautiful shapes. A higher power would unfold new beauties in those which we can observe and bring into view thousands which we cannot detect. What untold numbers each square inch of these substances must contain!"

The children gazed eagerly at this specimen, and were filled with wondering admiration at the marvelous revelation. They looked at the little bits of marble and chalk with a new conception: they had lost their insignificance.

"But," said Alf Green, who could not be wholly cured of his skepticism, "you don't mean to say, Mr. Willard, that a gun-flint—one that strikes fire is made up of animals?"

"Well, Master Alf," replied the teacher, "I do not wonder at your astonishment, but the fact is easily proved. Here we have a thin scale of flint, and if you doubt its being so, you can break off a thin piece from this one which you have brought



Flint Magnified.

yourselves, from which I obtained the specimen which I now show you.

"Now look, Master Green, and tell the school what you see."

"Oh, I see," exclaimed the admiring scholar, "a whole lot of stars and suns with rays sticking out all around!"

"Pretty good," replied the teacher; "those points do look as if they would stick a little, and if we magnify them a little more, we shall find that each point is pronged like a fork. These curious outlines

which have excited your admiration are the shells of animalcules, but, as you see, death has not robbed them of their beauty.

"In Norway and Lapland there is a species of minute fossil called Berg Mehl, which forms a strata more than thirty feet thick.

The natives call it 'mountain-meal,' for in times of scarcity great quantities are gathered and mixed with their coarse meal and baked into bread. It is. as can be readily seen, composed of the fossil shells of diatoms, mostly of the species called navicula

"We have thus seen that these infinitesimal dead compose stone, flint, gem, and meal, and here we should suppose their dominion would cease: but no, they run almost through





Spicula of Flint,



the mineral kingdom. The 'Bog Iron Ore,' we are told by Ehrenberg and other writers, is largely composed of these relics of minute life, and where else we shall

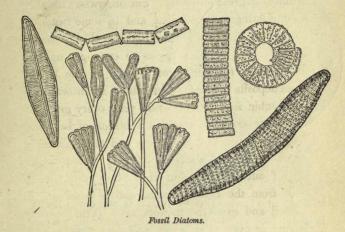
find them we can hardly tell, but must await the further developments of science.

"We must not suppose that these fossil forms are confined to great antiquity. Far otherwise; they are accumulating every moment, and in some instances with great rapidity. In the Red Sea this process is going on with such energy as to endanger navigation, and in the harbor of Wismar, in the Baltic, these deposits increase at the rate of seventeen thousand cubic feet of mud every year, every grain of which, we are told, contains a billion of beautiful silicious shells! In Barbadoes and other places a similar process is filling up the sea. What can we say of such things but that 'this also cometh forth from the Lord of hosts, who is wonderful in council and excellent in working'? Truly it may be said in other than a spiritual sense that we cannot fly from his presence; on land or to the uttermost parts of the sea he is equally and palpably present in his wonderful works.

"Let us take a more particular notice of some of these palaces of a minute race.

"I have told you that the diatoms were among the first born of life, perhaps the very first, and that they have come down to us in an uninterrupted descent; hence we might expect to find them most numerous and most generally diffused—a fact which

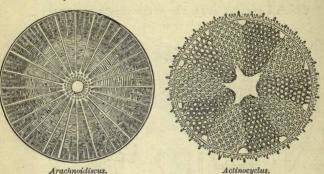
is verified by all researches. They are found in all the living forms which we have noticed, but these which I present are perhaps the most numerous.



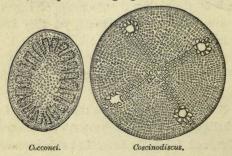
"These navicula shells are older, no doubt, by thousands of years, than the mummies of Egypt, as their tombs were the flinty rocks, yet they are as perfect in shape and fresh in outline as their living compeers so lately under our instruments. No wonder they are so highly treasured by the microscopist.

"In Bermuda and Barbadoes these forms of infusorial shells are found in the greatest abundance and perfection, and I am fortunate in having secured a

number of well-mounted specimens. Here are two with very hard names:



"How beautifully the last named is striped and dotted, with a delicate lace-work edge, and starred in the centre! Seeming so frail, it is wonderful that it is not broken into pieces in the process of washing and mounting, yet it will not only endure this treatment, but pass through great heat also.



"Akin to these, but of smaller dimensions, are the little oval *Cocconei* and the *Coscinodiscus*. This last is worthy of notice, from the elegant cross bars dividing it into sections, with delicate rosettes at the terminations.

"The Isthmia is very attractive from its peculiar

shape and delicate penciling, and the attachment of a second shell to the parent, indicating the manner of its reproduction. At some point near the middle of the parent cell a bud is

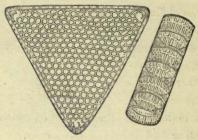


Isthmia.

seen to protrude, and with steady progress develops into a perfect animal, when it rudely breaks away. In our specimen death has arrested the process; like the monarch of Israel and Jonathan, 'they were lovely in their lives, and in death they were not divided.'

"Two most remarkable of this class of microscopic objects are the Gallionella and the Triceratum. The Gallionella is widely scattered over the United States, in many parts of which I have obtained beautiful specimens, and is often termed the 'Boxchain animalcule.' When only one end of the

chain is seen, it has much the appearance of a small coin, but turned lengthwise it is found to consist of twenty or more of these coin-like sections. In this shape they are perceptible to the eye on close inspection as a fine thread-like filament running through the limestone rock in which they abound.

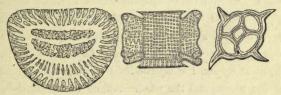


Gallionella and Triceratum.

"The other specimen is a beautiful honey-comb triangle, of very attractive appearance. Both of these forms have their living representatives in our ponds and ditches, and are said to multiply so fast that one hundred and forty millions of these subsections are produced every twenty-four hours. No wonder that they build up mountains in thousands of years!

"The last examples which time will permit us to examine are the *Campylodiscus*, *Amphitetra*, and *Dictyocha*. They are given because we saw them

abundantly in the living state, and we can see how little change death has made in their appearance. Their bright colors have faded a little, but the tenement has not been shattered by the hand that dashed its inner life out. They are beautiful shapings, giving almost every angle known to geometry. With



Campylodiscus, Amphiletra, and Dictyocha.

these frail materials God rears up the sublime structures of nature, and who but the almighty One from such beginnings could bring to pass such stupendous results? From nothing he has all things made!

"With this overwhelming, solemn thought we will take our leave for the present of these infinitesimal forms of life. In doing this, how profound the impression! The means, how far beyond our conception and knowledge! The result, how baffling our comprehension! The one we must search for with eyes wonderfully assisted; the other meets us with its grand realities—incomprehensible at either extreme, but meeting us in the medium with the tangible certainties of creation.

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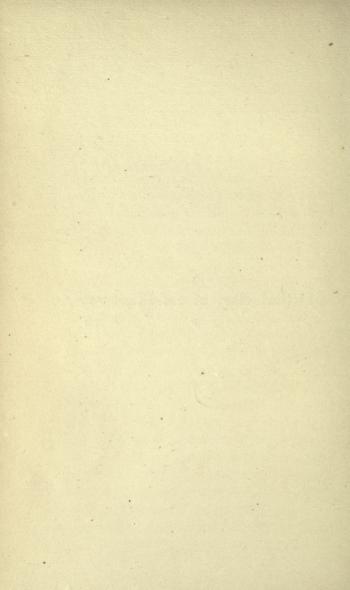
"Who can resist the lesson which says to us so impressively, 'Trifle not with aught which God has created, for he may use it to curse thee; despise it not, for he may make it a blessing to thee'? He may withdraw the animalcule from the ditch or pond, and the destroyer will start up from its pestilential waters; or give his commands to his invisible army of motes that 'people the sunbeam,' and they will enter into the nostrils and creep into the pores of the skin, and the cholera will sweep off its thousands. A little fly shall sting the fruit or eat out the germ of the wheat, and the whole staff of bread shall be cut off. How true it is that whole nations 'perish from the way when his wrath is kindled but a little!' What a fearful thing it is to trifle with God!—that God who does not trifle with the minutest thing which he has created! Because he made it, it is no trifling thing.

"My dear pupils, my efforts will have accomplished very little if I have not succeeded in impressing you with this solemn truth. If you must not trifle with the least of the things which he has made, how much greater the offence to treat lightly your own precious souls! Your bodies are but the soul's casing. Like these fossils, they will soon be entombed, resolved back to dust and commingled with diatom and foraminifera, but what of the soul?

We cannot trace its flight with the telescope, nor find its hidden dwelling with the microscope. The body will return to the dust, whence it came, but the soul shall go to God who gave it; and the all-important question is, How shall we stand before him? May the wonder and astonishment which our lessons have excited at the marvels of his creating hand lead us to the greater marvel of his grace in the gift of his only begotten Son for our redemption!

"Our next interview will be devoted to the practical uses of the microscope."

Practical Uses of the Microscope.



CHAPTER XVI.

PRACTICAL USES OF THE MICROSCOPE.

THE welcome hour found the children gathered around the familiar table, as eager as ever to listen to their loving teacher and inspect the strange things which he had to show them. Mr. Willard began by saying:

"The girls have provided us with a beautiful collection of butterflies, millers, moths, and other insects, and we could spend many pleasant hours in examining their structure, habits, and beautiful wings, but nearly all these interesting facts you can learn without the use of the microscope. To aid you in this I have some copies of a book recently published, the 'Wonders of Insect Life,' by Professor Willet, which I recommend you all to read. It is full of interesting information on this subject, and will save us the necessity of spending much time in the investigation of insect life. To any one who will take the pains to observe, the curious ways and structure of many a familiar bug will excite a great degree of interest, which will be vastly increased

when the object is placed under the microscope. It is only thus we discover that the down on a butterfly's wing is composed of beautiful plumes vieing with the splendors of the peacock, and that some of the shells are studded with sparkling gems. By this power the masses of larva are transformed into pearls and beads of rare form and workmanship, and legs and horns become wonders of mechanism. With a knowledge of these facts we are never at a loss for objects of study. If we cannot obtain water from the pool or marl from the pit, we have only to capture the common house fly, cockroach, or miller, and we have abundant resources to engage our attention. The eye of hundreds of lenses, the suction foot, the sharp sting, the variegated wing, the coiled proboscis, or hairy antennæ,—all these will repay the pains taken to examine them. Indeed, the objects of microscopical interest are almost limitless; the animal and vegetable creations are never-failing resources. The leaves and pollen of flowers, pores and fibres of wood, moss and lichens, texture of bones and shells, skin, hair, and nails, blood and other fluids of the human body, -in short, there is nothing capable of being adjusted to the powers of these wonderful glasses but is invested with a new and strange interest.

"But you must not suppose that the only value of

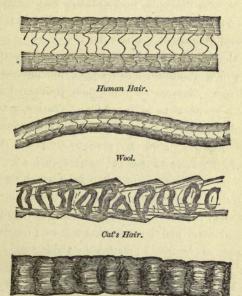
the microscope consists in its wonderful powers of revelation. This would, indeed, give it a rare value, and justify all the attention which has been given to its perfection, but it has a practical worth which must not be overlooked, and this worth is every year becoming more and more apparent. There are few departments of human effort that do not require its aid in detecting fraud or enlarging resources. It has become the most prized handmaid of Science and Art, it ministers to the relief of suffering in the hands of the physician, and the detection and punishment of crime in the courts of justice. Of this last benefit I have given you two examples in tracing the guilt of the criminals by the blood-marks which they had left.

"But it is not only used on this bloody scent: a single hair is often all that is presented to its searching inspection. There was a case of this kind a few years since. An old lady had been brutally murdered and thrown out of an upper window, the murderer hoping thereby to give the impression that she was killed by a fall. But the head was cut and bruised in a manner which made it impossible that this should have been the mode of her death. In the search for causes a poker was found with bloody stains, which, with some others taken from the shirt sleeves of a son-in-law, were taken to an expert. In

searching these, a single gray hair was found adhering to the sharp end of the poker, which had been driven into the head. This hair was identified as belonging to the murdered woman, and established the fact that this instrument had been used in her destruction, entirely overthrowing the theory of the prisoner that she had accidentally fallen from the window. It is, therefore, literally true that life sometimes hangs on a single hair.

"There is an anecdote which strikingly illustrates the almost infallible testimony of the microscope, even when hundreds of years have transpired after the event has taken place which it is called upon to elucidate. A few years since, in making some repairs in an old church in Yorkshire, England, a few bits of dried parchment or skin were taken from under the heads of some large nails which studded the doors. They excited so much curiosity that they were taken to an expert microscopist for examination. Placed under his instrument, he pronounced them to be pieces of human skin-that of a man of light complexion, for the well-defined human hair was still fast in the skin and perfect in its preservation. To verify these statements search was made in the old parish records, when it was found that near a thousand years before a Danish robber had broken into and robbed this church, and for a pun-

ishment had been flayed and his skin nailed to the church door. On all the portions of the skin exposed to the weather time had done its work of destruction, but the broad-headed nails had preserved those portions concealed under them to give this testimony of the long-past event.



Hair of Mouse.

"Like the blood, God has given to the hairs of each species a distinct individuality, which the mi-

croscope brings out with unerring certainty, and it can identify, in most instances, that of different individuals of the same species, as in the case of the murdered woman just mentioned. Let us take a few specimens.

"Here is a sample of human hair. It is cylindrical, with fine wayy lines running parallel around it. All human hair is not exactly like this, but the general characteristics are the same, and mark its identity. It is in some respects analogous to the stem of a plant growing by continual additions at the root. Internally it is much the same, being made up of a large number of fibres which are capable of separation, like those of wood, hence 'splitting a hair' is no metaphor. It is said by those who have examined its structure with very high powers that a single hair is made up of more than fifty thousand fibrils, being finer than those of any other known tissue. Pull out one of your hairs, and then try and imagine that this vast number of threads are wrapped together in a thing so attenuated! God's spindles spin finely. Not only are the hairs of your heads all numbered, but his hand has spun out each invisible fibril and wove them together for a covering to your head, and a glorious adorning it is.

"The following anecdote, taken from the American

Journal of Microscopy for May, 1871, will show how much may hang on a single hair, and how certainly the microscope will bring out its testimony:

"Some time ago, being in company with a medical man, whom I will call Mr. R—, we fell into conversation on the uses of the microscope, in the management of which he was an adept.

"'Now,' said he, 'I will tell you a story of what happened to myself—one which, I think, well illustrates the importance of this instrument to society, though I was put in a very unpleasant position owing to my acquaintance with it.

"I have, as you know, given a good deal of attention to comparative anatomy, especially to the structure of the hair as it appears under the microscope. To the unassisted eye, indeed, all hair appears very much alike, except as it is long or short, dark or fair, straight or curly, coarse or fine. Under the microscope, however, the case is very different; the white man's is round, the negro's oval, the mouse's apparently jointed, the bat's jagged, and so on. Indeed, every animal has hair of a peculiar character, and what is more, this character varies according to the part of the body from which it is taken—an important circumstance, as will appear from my story, which is this:

[&]quot;'I once received a letter by post containing a

few hairs, with a request that I would examine them, and adding that they would be called for in a few days. Accordingly, I submitted the hairs to the microscope, when I discovered that they were from the human eyebrow, and had been bruised. I made a note to this effect, and folded it up with the hairs in an envelope, ready for the person who had sent them. In a few days a stranger called and inquired whether I had made the investigation. "Oh yes," I said, "there they are, and you will find them and their description in this envelope," handing it to him at the same time. He expressed himself as being much obliged, and offered me a fee, which, however, I declined, telling him that I could not think of taking anything for so small a matter.

"It turned out, however, of more consequence than I imagined, for within a week I was served with a subpœna to attend as a witness in a trial for murder. This was very disagreeable, as I have said, but there was no help for it now. The case was this: A man had been killed by a blow from some blunt instrument on the eyebrow, and the hair sent to me for examination had been taken from a hammer in possession of the suspected murderer. I was put into the witness-stand, and my testimony that the hairs were from the human eyebrow, and had been bruised, was just the link in the chain of

evidence which sufficed to convict the prisoner. The jury, however, were not easily satisfied that my statement was worth anything, and it required the solemn assurance of the judge that such a conclusion was within the reach of science to convince them that they might act upon it.

"'One juryman in particular, an old farmer, was very hard to satisfy. "Does thee mean to say," said he, "that thee can tell the hair of any animal?" I answered that I would not take upon myself to assert positively that I could do so, although I believed I could. "Well," said he, "I'll prove thee."

"'The prisoner, as I said, was convicted, and I went home, and in the busy life of an extensive practice forgot all about my obstinate old farmer. About two years afterward, however, a person an utter stranger to me called on me with a few hairs screwed up in a piece of paper, which he asked me to examine and report on. "Is this a murder case?" I inquired; "for if so, I will have nothing to do with it. I've had enough of that sort of work." "No, no!" said he, "it is nothing of the kind. It is only a matter of curiosity, which I should be very much obliged if you would solve; and if you will do it, I will call or send for the result of your examination in a few days' time." Having received this assurance, I undertook the investigation.

"'When he was gone, and I had leisure, I put the hairs under the microscope, and soon discovered that they were taken from the back of a Norway rat. Two or three days afterward, as I was sitting in my consulting-room, an old farmer-looking man was ushered in. "Well," said he, "has thee looked at them hairs?" "Yes," I answered, "and I find that they are from the back of a Norway rat." "Well," exclaimed he, "so they are. Thou hast forgotten me, but I have not forgotten thee. Does thee recollect the trial for murder at L-assizes? I said I would prove thee, and so I have, for them hairs came from the back of a rat's skin my son sent me from Norway." So the old gentleman was quite satisfied with the proof to which he had put me, and I. as you may suppose, was well pleased that my skill and sagacity had stood such a queer proof as this, and more convinced than ever of the value of the microscope.'

"Here the doctor's story ended, which I have given as nearly as possible in his own words, and upon which I believe that a thorough dependence may be placed.

"A very similar case is given in Prof. Richardson's late work on *Medical Microscopy*, occurring at Norwich, England, about the year 1850.

"A female child nine years old was found lying

on the ground in a small plantation, quite dead, with a large gash in the throat. Suspicion fell upon the mother of the murdered girl, who, upon being taken into custody, behaved with the utmost coolness, and admitted having taken her child to the plantation where the body was found, whence the child was lost in the quest of flowers. Upon being searched, there was found in the woman's possession a large and sharp knife, which was at once subjected to a minute and careful examination. Nothing, however, was found upon it, with the exception of a few pieces of hair adhering to the handle so exceedingly small as to be scarcely visible. The examination being conducted in the presence of the prisoner, and the officer remarking, 'Here is a bit of fur or hair on the handle of your knife,' the woman immediately replied, 'Yes, I dare say there is, and very likely some stains of blood, for as I came home I found a rabbit caught in a snare, and cut its throat with the knife.' The knife was sent to London, and, with the particles of hair, subjected to a microscopic examination. No trace of blood could at first be detected upon the weapon, which appeared to have been washed, but upon separating the horn handle from its iron lining it was found that between the two a fluid had penetrated which turned out to be bloodcertainly not the blood of a rabbit, but bearing

every resemblance to that of the human body. The hair was then submitted to an examination. Without knowing anything of the facts of the case, the microscopist immediately declared the hair to be that of a squirrel. Now, around the neck of the child at the time of the murder there was a tippet or 'victorine,' over which the knife, by whomsoever held, must have glided, and this victorine was of squirrel's fur!

"This strong circumstantial evidence of the guilt of the prisoner was deemed by the jury sufficient for a conviction, and whilst awaiting execution the wretched woman fully confessed her crime.

"Ah, how our wonderful instrument peeped into the hidden crevice of the knife-handle to bring out the bloody testimony, and searched along the sinussities of the squirrel's hair to point out the dreadful crime of that wicked mother! No human eye could have brought to light such guilt without its aid, and the inhuman parent might have lived to slaughter another innocent.

"The fibre of wool, placed near the human hair, can be easily distinguished by its texture and markings, the points of the circular lines being much sharper. The hair of the domestic cat is of curious formation, seeming to be a succession of steps enclosing a series of semi-transparent masses, to which,

probably, we may assign the electrical phenomena which pussy exhibits in the winter evening. The hair of the mouse is entirely dissimilar. These examples will be sufficient to illustrate the marked variations of hair and show how easily they can be distinguished one from the other.

"Bones have about the same variety of texture in different animals, and in the several parts of the same animal, by which the skillful observer can not only fix the species, but the exact part of the skeleton from which any particular bone is taken. This rule will apply also, with not quite so much certainty, to the muscles and cartilage, secretions, and other components of the body.

"From these considerations we can see what an invaluable instrument the microscope is to the physician. With it he can not only fix the location of the parts of the body, but determine the condition, whether healthy or diseased, and thus be better prepared to apply the remedy. Had it not been for the microscope we should never have known the cause of death when the terrible *Trichina* have been at work. Knowing now the cause, a remedy may be discovered to check his fatal work. It is now said to be shown, by the same process, that the terrible cancer is owing to a fungoid growth sucking away by its rapid increase the vitality of the parts until it eats the poor

victim's life out. If this be so, let us hope that a sure antidote will be yet discovered for this most painful malady.

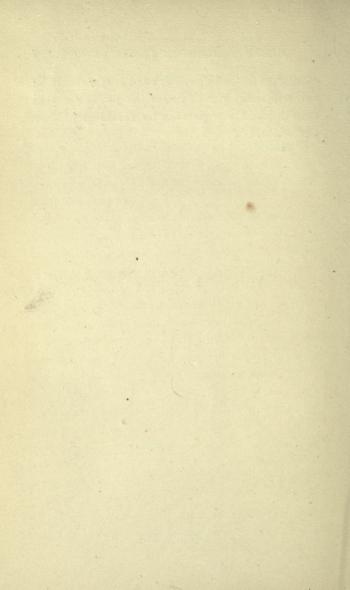
"These examples will show what cause of gratitude we have for the discovery of the microscope. In the hands of skillful men it becomes a precious boon to suffering humanity, lessening many of its pains and dangers.

"A curious instance of the detection of crime by the microscope occurred in Germany some years ago. In transacting some banking business it became necessary to transfer several boxes of gold from one city to another. The boxes arrived in due time, but, when opened, the precious metal had mysteriously disappeared: its place was occupied by a peculiar species of sand. All efforts to detect the robber utterly failed, until some one acquainted with the use of the microscope suggested an examination of the sand found in the boxes. This was done, and its characteristics established, and then specimens of sand were taken from every station on the line of railroad and subjected to a similar process; in this way the place of the robbery was easily fixed upon, and this led to the ultimate arrest and punishment of the thief.

"These instances will show the great practical value of the microscope in the jurisprudence of our

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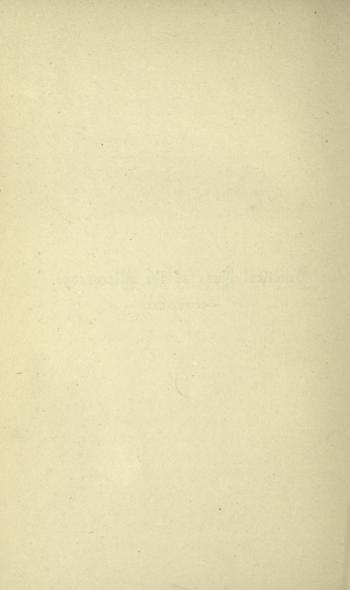
country, so that both physician and lawyer should be well acquainted with its use, or the public will hold them deficient in preparation for the duties of their professions."



Practical Cises of the Microscope.

-CONTINUED.

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CHAPTER XVII.

PRACTICAL USES OF THE MICROSCOPE .- Continued.

FTER a few minutes' intermission, Mr. Willard resumed his discussion by remarking, "To Science and Art the microscope has become an indispensable assistant. With this instrument and the solar spectrum the gases and minerals of the planets are clearly determined—one of the most wonderful achievements of science. Most of you are aware of the effect of a prism of glass in separating the rays of the sun into the seven primary colors. You can thus make a ribbon of light, with the different colors running across it, as in some of the ribbons which the girls wear. By the same process it is found that the light from the different gases and burning minerals produces specific lines across the ribbon without regard to the distance at which the observation is made. To demonstrate the conditions of the atmosphere or substance of one of the planets, an apparatus called a spectroscope is used, and a photographic picture taken in which the light will be represented by a uniform line, invisible, it may 24* 281

be, to the unaided vision, but with our faithful instrument these lines can be examined and the nature of the substance which caused them determined with great certainty. By this wonderful process many of the minerals with which we are familiar on earth are shown to exist in the sun, moon, and some of the planets. As this study is just in its infancy, the astonishing results already obtained warrant the expectation of discoveries of the greatest magnitude, and before long we may expect to know what the moon is made of as familiarly as we do the composition of the earth on which we tread.

"There is a combination of the telescope and microscope from which we may expect most astonishing results. The former instrument has been brought to such perfection and power that objects on the moon's surface seventy feet in diameter can be easily distinguished. Photographs taken with such powerful instruments can be placed under the microscope, and examined with great care. By this process we may be able to inspect all the secrets of the moon, and if there is animal life existing on its surface determine its forms and conditions. There is little doubt that another generation will be almost as familiar with the physical conditions of the moon as we are with the earth: perhaps we ourselves may reach this knowledge.

"The microscope is exceedingly interesting and useful in all manipulations of iron and steel, both as revealing the rare beauties of their structure and determining their quality. I have some specimens which we will put under our instruments. This iron, you notice, is composed of crystals in the form of double pyramids; the smallness of the crystals and the height of the pyramids are in proportion to the quality and the density of the metal. In pig iron the crystals approach more nearly the cubic form, while that which has undergone the process of the forge has its pyramids flattened and reduced to parallel leaves. In the best steel the crystals are disposed in parallel lines, each crystal filling the interstices between the angles of those adjoining. The axes of the crystals are always in the direction of percussion they have undergone. Fine steel, under the microscope, presents to the eye large groups of beautiful crystals brilliant as a string of diamonds.

"By this inspection you will notice that the finest and most dense steel is quite porous—a fact which could hardly be admitted were it not for the unmistakable testimony of our wonderful optics, which, though not exactly capable of looking through a bar of steel, can nevertheless look into it.

"The microscope has started an earnest discussion of the topic of 'cell formation,' now exciting

patient and careful investigation, and which has already established the principle that animal and vegetable structures owe their growth alike to its operation, though differing widely in the elements of which they are composed. Yet when presented to us in their earlier developments there is little to distinguish between the animal and the vegetable. They are an aggregation of transparent cells. Too little has as yet been settled to speak with positiveness, but enough is known to show that animal and vegetable start from much the same point and advance much in the same way. It is a simple semi-transparent globule, with a shell much like an egg, with contents holding a nucleus. These cells multiply and change, all directed by the same unerring wisdom to that point which they are designed to build up. And what curious roads they travel to reach their destiny!—quarreling not on the way, whether their pathway is down to the foot or up to the head, to sparkle in the eye or indurate in the nail. They troop away through the pores of the bones and cluster in the muscle, spin out the network of nerves and ringlets of hair, pour in the currents of blood, swarm in the fluid secretions, busy, restless little workers, building up the blade and fruit, or developing the infant into manhood.

"While we wonder at this 'beginning of life,' it

may humble us a little to see that our growth is like that of a pumpkin—at least, if there is a difference, the most observant have not yet been able to point it out. The only marked difference now established is the process by which this germ-life is nourished into complete development. The animal molecule is fed from within on organic compounds by the mysterious process of digestion and assimilation, while the plant germ feeds on inorganic elements from without, taking up through the pores and distributing through ducts to branch and leaf.

"We have seen in the volvocines and confervoid algæ that these plant germs have something very near the power of independent motion, leaving many in doubt to which class they belong. Here, if anywhere, we might have expected some intimation of a 'development' process, if it anywhere existed. Just here, where it is difficult, in looking at the germ-cell, to determine whether it is the beginning of a cabbage or an elephant, a monkey or a Darwin, we might expect from the same seminal source to see start up all these diversities of life, but not so: 'like begets like,' and 'seed bears seed after its kind,' as uniformly as the day follows night; and, as has already been stated, the diatom of to-day is in the exact image and likeness of those gathered from the dust of the pyramids or dug from the base of the

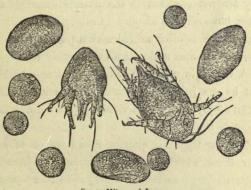
ancient hills. The bulrush of the Nile that now bends to its ripple is the same as those which formed the cradle of Moses. Darwin could not have been familiar with the microscope, or perhaps he would not have written his book.

"To those engaged in traffic and commerce who wish to deal honestly with their customers, it becomes a protection against the craftiness of dishonest manufacturers and tradesmen. By its use they detect, with unerring certainty, all mixtures of cotton or wool in the texture of silk goods, or shoddy with the woolen. The druggist saves his customers from the fatal consequences of impure drugs and chemicals, and the banker detects the cheats of the counterfeiter.

"In the hands of the groceryman and provision-dealer the microscope is invaluable to us all, saving us from many a vile compound. There is hardly an article which passes through the hands of those dealers—tea, coffee, flour, sugar—but is adulterated by unscrupulous men regardless of taste or health. So cunning are they in their deceptions oftentimes that nothing but the stern, truth-telling microscope can detect their craftiness. God has stamped everything with an individuality which no cunning of man can efface. Mix and cover up as they may, this divine identity will look up through the instru-

ment as though saying, 'I am true, though man is trying to make me a deceiver.'

"We all love sweet things, and pure, well-clarified sugar is very nutritious as well as agreeable. But crude or stale from long keeping, or damp from improper storage, it is a mass of animated impurities. You have often seen greedy boys scraping the sugarcasks before a sugar-house or grocery-store. That you may see just what they were eating, we will take a sample obtained by the girls from the grocery on the corner. We will take but a grain or two and moisten it a little and place it under the instruments. As I have not examined the specimen, I know not



Sugar Mites and Larva.

what it may contain, but I am quite sure there will be no lack of elements which will give you a new understanding of the oft-repeated phrase in the current price quotation, that 'sugar is lively.' Now look and see how near I was to truth in my supposition. Why do you start back so suddenly, Nettie?" said Mr. Willard to the little girl as she turned away from the instrument with an expression of disgust.

"Oh dear!" was her reply; "I'll never touch another bit of sugar! Such horrid creatures!"

"They are not the most inviting things to the appetite, truly," replied her teacher, "but as you are not much given to scraping sugar-barrels, you can indulge a little in sweet things yet without much fear of swallowing many of these fearful creatures. They are not confined to the barrels found on the streets, however, but abound in all crude and damp sugar, which is often mixed with a purer article by unscrupulous men and sold for the family use.

"A writer in a New York paper thus describes what he saw in a few grains of crude sugar, which we can amply verify with the examples we are now inspecting:

"'In less than the quarter of an ounce of raw sugar there were apparently myriads of horrible insects as large as beetles and having the appearance of crabs. Four dreadful legs, with claw-pincers at the end of them, jointed in four parts as with armor, and bristling with sharp-pointed spears, were in front of the monster, and his head was of a long pyramidal form in two joints, with finger-tips at the terminus where the mouth ought to have been. The body was oval-shaped and marked almost exactly like that of a crab, only upon the rims of the inner circle, upon the back, there were twelve more of these long sharp spears, with two at the tail, and four snake-like tentacula excedingly fine in articulation, and no doubt intended, like pussy's whiskers, to be feelers, to warn the hinder and contiguous parts of danger.

"'Talk about lively beasts! and lively they were, eager, restless, ravenous, always falling foul of each other, or attacking great joints of sugar as large in reality as a mathematical point. With the pincers attached at the end of each proboscis they caught hold of each other and tore one another to pieces, repeating in their small way the enormous tragedies of Tennyson's primal monsters.'

"Dr. Barker, of London, has estimated that in every pound of raw or damaged sugar there are more than two hundred and sixty-eight thousand of these animals, so that every little boot-black who scrapes his fill from the sugar-house hogshead gets a pretty large mixture of animal diet with his sweetness.

"Well-clarified sugar kept in proper receptacles

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is entirely free from these disgusting creatures, and by the use of a very low power we can prevent being victimized by dishonest dealers.

"But in the more important article of flour we are exposed to the same imposition. If stale, made from bad wheat, or mixed with these damaged arti-



Meal Mite.

cles, it breeds an equally offensive creature—the Meal These vermin are not quite so numerous as the sugar mite, but quite as plentiful as is desired.

In this mouldy flour obtained by the girls we have numbers of them, but that you may see how terrible they are I have a larger specimen mounted. Look at his spiny body, like a porcupine, and those long legs with a sharp hook at the termination, and I think you will not fancy eating a large quantity. If, however, dishonest millers and grocerymen sell them to us, it is a satisfaction to know that they are pretty well cooked before they come on the table, though, even in that shape, we can dispense with them as an article of diet.

"Unfortunately, our bread is not only exposed to the infusion of these terrible mites, but also to many deleterious substances, as plaster, terra alba, and potato starch, all of which can be just as easily detected by the microscope. In like manner, our coffee is mixed with chicory, wheat, peas, rye, and many other substances, until there is no safety in buying coffee, except in the raw state, and even then it must be carefully examined or we shall find our supplies mixed with thorn-apple seeds or sunflower grains, and its delicate aroma ruined. Tea is tampered with in the same way by using leaves of plants bearing a similar shape, and often colored by the use of some poisonous mineral, blue vitriol being largely used for this purpose, and few specimens of tea can now be obtained without the evidence of

these wicked adulterations, which, if not checked, may lead to the necessity of discarding its use altogether—an event, perhaps, not very alarming, but very disagreeable to those who are much attached to the pleasant beverage.

"Another very striking and beautiful use of the microscope is seen in its nice adaptation to sanitary purposes, detecting the miasmic poisons that may lurk unseen, save for its aid, in the atmosphere. This is readily done by covering a glass plate with a thin coating of mucilage and exposing it to a current of air for a short time, then washing off the collection and putting it under the instrument. Mr. Dancer tried this experiment in Manchester, England, and from twenty-five cubic feet of air obtained one hundred and fifty drops of liquid, in which there were more than forty million of organic beings. Now, when we remember that this quantity of air is only a small portion of that which is breathed by every man in twenty-four hours, we cease to wonder that he so often breathes in death in our greater marvel that he lives at all in such an atmosphere. In New York the same process has been tried by the health officers, only varied by taking the fine dust that settled on a plate of glass, and this accumulation was found to consist of minerals, coal dust, lampblack, fibres of wool, scales, granules of starch,

hairs, etc., and when water was added, and the contents exposed for half a day to the sun, thousands of animalcules made their appearance. All this from the surface of a small plate of glass. What, then, must be the product of the whole teeming city? We ought to bless God that the breath of our nostrils comes through his purifying hand, or it would be speedily fatal.

"Similar experiments made in factories, armories, furnaces, and machine shops prove that the employés are constantly inhaling the minute particles of the materials which they are using. Thus in the Springfield armory the air was found impregnated with emery and sharp, jagged pieces of steel and iron too small to be detected by the unaided eye, but constantly going into the lungs of the operatives. It is well that Nature has provided such barriers as prevent these sharp lancets from going far into these vital organs, or the most fatal results would speedily follow.

"To the antiquary the microscope possesses a peculiar value, enabling him to make important discoveries, deciphering illegible inscriptions on old coins and ancient jewelry and tracing out the faded writing of mouldy manuscripts. However minute or dim, this wonderful eye will trace it all out. Here is a slide with a small circle in the centre. I will

wipe it carefully and let you examine it. Now pass it round, and if any scholar can detect any object within the circle he will please name it. You find nothing? Well, that is what I expected. We will now see how one of our instruments will succeed. Ah, it has sharper vision than we have. I now read: 'Exodus, Chap. xx., 1-17,' and by moving the slide gently I can plainly observe all the Divine commandments. God's sun-pencil has written them all within a space so small that no unaided eye can detect them, and thus the antiquarian uses the microscope to bring to light many hidden things of the greatest importance to history, science, and religion. Oftentimes he has found that parchments have been used several times, one writing being erased to give place for another.

"During the recent war between Prussia and France, when Paris was surrounded by the army of the former, the only way to communicate with the world outside of the walls was by balloons or carrier pigeons, which could convey but a small weight of a few ounces. Had the Parisians been confined to the ordinary methods of writing, very little intelligence would have passed beyond the city limits or have returned by these faithful birds. But the French are most skillful in the construction and uses of the microscope, and were not long in finding

out the way of putting it to a practical use. Being as expert in the use of the photographic art as of the microscope, whole pages of a newspaper or written document were photographed in the small space of a dime on fine vellum and numerous copies taken, and in this manner a single pigeon could transport quite a respectable mail from and to the beleaguered city.

"Thus we have only glanced at some of the ways in which the microscope is made conducive to the happiness of man, but they are quite sufficient to give it a position of utility equal to almost any other invention. Add this to the marvelous forms of a new life to which it has introduced us, and our little brass tube becomes invested with surpassing interest, giving it a rank with the telescope, telegraph, and steam-engine, and in some respects surpassing them. With these facts before you, I am sure I need not urge your further acquaintance with it, not doubting that you have become so interested with its wonderful revelations that you will gladly devote any occasional hours which I may be able to set apart for further investigations. You have become so familiar with the management of the instrument during these interviews that most of you can now pursue your investigations without my aid, which I most earnestly urge all to do who can procure a cheap instrument, which will be ample for all practical purposes. Should you meet with difficulties in so doing, it will ever give me the greatest pleasure to aid your researches by any instructions necessary to your success.

"Monday afternoon will close our menagerie, not because we have exhausted its wonders, or become tired of gazing at those most familiar to us, but other duties will claim our attention.

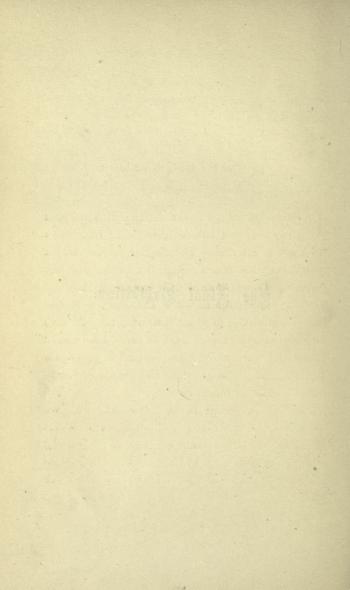
"The interest connected with the traveling show which lately visited our place has quite died away, and it is doubtful whether it left any beneficial results. Not so, I trust, will be the influence of our many pleasant interviews. Each one had its special interest and left a definite impression. It taught us something which we shall ever remember. It changed our entire views of some parts of the visible creation and enhanced our conception of the Creator. Our thoughts will no longer be confined to that which is sublime from its vastness, but will often recur with increased wonder to the minute things which have been made equally as well known to our senses. The ditch will no longer be a mere collection of impure water, nor the lump of chalk a mere trifle to be left for the carpenter's use. In both, our minds will see the wonderful forms hidden within them. This quickening of the senses is a gain for

all life, and my ardent prayer is that our study may lead to the quickening of that moral sense which will gain an immortal life. Our moral vision is as obtuse to spiritual things as our eyes unaided are to the hidden things which we have been examining. You will commiserate those who cannot see these minute forms of life as you can see them. They have the same eyes which you have, but theirs have not been quickened to behold the things which you see. There are more precious truths than can be revealed by our wonderful instruments, yet I fear many of you are as unconscious of their existence as you were a short time ago of the strange forms with which you are now so familiar. greatest wonder ever revealed to the world is that blessed Saviour who came into the world to save the souls of men; and, alas! to some of you I must yet say: 'Behold the Lamb of God, who taketh away the sin of the world.' From our delightful study of the wonderful works of the same gracious Redeemer-for 'all things were made by him'-you will go with a determination to use the sharp eyes which he has given you, and can you make the sad mistake, while looking at his marvelous works, not to see him who created all these things? And seeing him, can you refrain from loving him with all your hearts for his goodness and mercy? If you

fail in this, all your knowledge will be vain, and your pleasure end in ceaseless pain. I would rather be the means of showing you the blessed Jesus than unveil to you all the mysteries which he has created. With this expression of my great anxiety for your spiritual welfare I will dismiss you, hoping that you will meditate upon these things, to which I may recur again in our next interview, which will close our exhibition for the present."

The Final Gxhibition.

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CHAPTER XVIII.

THE FINAL EXHIBITION.

It would be unjust to the children of Woodlawn to say that they left the presence of their faithful teacher, after such an affectionate admonition, with thoughtless hearts: mingled with the sober tenderness awakened toward their instructor, there was a really earnest seriousness. The question of that higher knowledge to which their attention had been directed had become, to some of them, a subject of paramount importance. They began to understand the true ends of knowledge, and cherished resolutions to make a proper use of it.

This was apparent in the promising religious awakening in the evangelical churches of Woodlawn, Mr. Willard's pupils being largely interested, traceable to his faithful instructions during the course of lectures which he had been giving. His last brief but pointed remarks seemed to have been most timely, and his young audience left his presence, each one feeling a personal interest in the subject. It

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was not strange, therefore, that an unusual solemnity was manifested in their deportment, and a silence which all seemed reluctant to break. This was, however, done by Timothy Allen, rallying his friend Alfred, to whom he said:

"Why, Alf, you're as sober as Parson Longface. What's the matter, boy?"

"Well, Tim," was the reply, "I'm not ashamed to acknowledge that I feel not only sober, but really anxious about myself. We have seen most wonderful things, and have been deeply interested in them, and I begin to feel that we have something more to do in the matter than simply to enjoy the intellectual pleasure. As Mr. Willard said to us, we must be dull and guilty to wonder at the work and not recognize and adore the Worker. Strange and marvelous as the revelations of the microscope have been, I'm more of a wonder to myself. If God has so carefully organized these minute forms, and given them a destiny, did he create you and me only to search them out and admire them? Did he not rather make them that, beholding his handiwork, it might lead the observer to glorify him? I feel as I never felt before the force of the lines we have often sung:

> "Tis not the whole of life to live, Nor all of death to die,"

and am determined to make a start for the right way, and with the Lord's help live more like a reasonable being."

Before Alfred had finished his frank confession Timothy was as sober as his fellow-student, and as frankly replied:

"Excuse me, Alfred; I did not mean any offence, for I've been as deeply impressed as you have been, and have many times wanted to give expression to my feelings, but could not muster up courage to do it. I know that life is a serious matter, and that to which it leads is more serious still, and, like you, I wish so to spend this life that I may meet the future without dread. Mr. Willard has given us not only hours of delight and lessons of most valuable instruction, but opened up to us higher aims and purposes, and, for one, I'm resolved and ready to openly avow my determination to pursue the path of right and truth."

George Snow and Willie Hunt had stood deeply interested spectators of this conversation, and at its close gave their hearty congratulations, and exhorted their young companions to persevere. They had been in the advance of their two companions in this matter of seeking a personal interest in the grace of Christ. As there was to be a special meeting of inquiry for the young on the next afternoon, they

invited their two friends to attend with them, which they most cordially accepted.

After this interesting arrangement was settled, another matter was discussed. Alfred Green, generous as impulsive, had suggested to his schoolmates the fitness of presenting to their teacher some token of their appreciation of his efforts to add to their happiness, and by general consent it was resolved to purchase a fine microscope, which had been accomplished mainly through Alfred's efforts, and the instrument was now ready for presentation. This pleasant service was, with the same unanimity, assigned to Alfred.

The meeting on Saturday was one of the deepest interest, and developed a much wider religious awakening than had been expected, especially among the attendants at Mr. Willard's school. George and Willie gave assured testimony of a living faith, while Alfred, Timothy, Sidney Marvin, Nettie Newton, and several others were among the most earnest inquirers. The Sunday which followed but confirmed these hopeful indications, and caused the church to rejoice under a gracious refreshing from the Spirit of the Lord.

Side by side with the earnest pastor, Mr. Willard was endeavoring to carry forward the good work, and the Lord gave him very special occasion for

rejoicing that he had not labored in vain nor spent his strength for naught.

On Monday, at the opening of the school, Mr. Willard read the fourth chapter of the first Epistle of John, which to a number of the scholars had a richness of meaning never before realized. It was no longer the mind dealing with grammar and rhetoric, but the heart delighting in the life-giving truths: they had got beyond the letter and were drinking in the Spirit.

When the regular routine of the day was gone through, and the children were gathered round the familiar table for the closing scene of these special interviews, there was an expression of sadness on most of those youthful faces, while little Nettie's eyes were filled with big tear-drops. Their kind teacher, whose own heart was kept under control only by strong efforts of the will, did not allow them to dwell long in this melancholy mood, for his cheerful voice soon dissipated the shadows that so easily cloud the faces of childhood. He began by saying:

"After the rich enjoyment of the holy day just passed, I scarcely feel an inclination to talk of anything but the richness of a Saviour's love. In comparison with this topic Science and the wonders of creation are as nothing, except as we view them as so many ways in which that love finds expression.

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In closing our microscopic examinations for the present, let us keep in view this relation of all things to Christ, and our minds will not be diverted from the great concerns which so engaged them yesterday.

"In our examinations we have been using powers of from fifty to six hundred diameters—that is, if a line was drawn straight through an object, it would appear six hundred times longer than it really is. Now, as every other line would be equally as much enlarged, to find the number of times a thing is magnified we multiply the diameter by itself; thus fifty gives twenty-five hundred, and six hundred diameters shows the object is magnified three hundred and sixty thousand times. You may, perhaps, think this is a very large number, and it has brought some strange things within the range of our vision, revealing a teeming life where nothing was suspected. What, then, must be the marvelous world to which a power of many millions would introduce us? Where we have suspected nothing under the limited range of our instruments, these stronger glasses would expose a still more marvelous kingdom of God's incomprehensible workmanship.

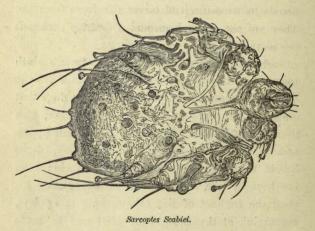
"A recent French savant, M. Plonchet, affirms that it is possible to magnify objects more than fifty millions of times—a number as much surpass-

ing the range of our instruments as these did the capacity of our own eyes. This statement of the Frenchman has been more than realized by a New York engineer, Mr. Dickerson. With his instrument a house fly is so magnified that, did it exist in just that proportion, it would cover a space half the size of the city of Washington. A man thus enlarged would be more than a hundred miles high, and a lady's hair stretched out for twenty-five or thirty miles. This instrument is so sensitive that a loud word spoken near it destroys the focus from the tremor of the atmosphere, and a footstep shakes it out of adjustment.

"The microscope has been called 'man's sixth sense,' but in view of such facts it almost endows him with a supernatural power: he sees things that are invisible! We are awestruck, and ask, Can these things be so? Though surpassing our apprehension, and almost our belief, our own eyes have beheld the borders of this mysterious world; what lies beyond, like the unknown scenes existing beyond the confines of this life, we long to explore, yet shrink at the thought of what may be made manifest. According to the learned Frenchman just named, we should find animalcules swarming in our mouths, swimming through our blood, creeping into our skin, and nestling in our bones, until we shudder

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at our fearful condition. In this respect it can be truly said that 'ignorance is bliss,' and we may add, perhaps without doing wisdom a wrong, that in this regard it is 'folly to be wise,' further than to accept the statement as an incentive to greater and persevering habits of personal cleanliness, for most of these parasitic animalcules are a scourge only to those who are neglectful in these respects. It is said that 'cleanliness is next to godliness,' and those who disregard the maxim will sooner or later find

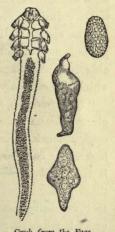


their hands infested with such fearful creatures as this which I now put under the glass, taken from between the fingers of 'Dirty Joe,' whom you see daily on the steps of the court-house blacking boots.

It is the loathsome Itch insect, which produces the sores existing between the fingers and around the joints of those infested with it. Buried in the skin. it breeds and fattens to punish the slovenly for their neglect. One look at its horrid claws and sucker mouth should be enough to ensure any one against its depredations.

"Oftentimes there will be seen faces specked here and there with little red or black pimples, produced by a grub which burrows in the skin of the face and

breeds by depositing its larva. They are not quite so disgusting as the last one named, but enough so to lead to persevering efforts to destroy them. This worm-like creature is often a judgment sent to punish those of improper habits as well as untidy persons, impressing the lesson which I have already enforced, that we are criminal in neglecting or abusing the bodies, so fearfully and wonderfully made, which God has given us. Dishonoring them. we dishonor their Maker.



Grub from the Face.

"It is not only necessary to keep the face and

hands clean, but the mouth and hair should be special objects of attention. I have already mentioned the fact asserted by the French savant, that the mouth is swarming with animalcules—a statement which you received with an incredulous smile. If I should show you the actual condition of some of your mouths, the smile would soon change to a 'wry face,' and your incredulity give way to a fixed determination to keep a 'sweet mouth' by the free use of soap and brush. If the mouth is neglected for a while, the teeth become coated with a slimy substance called tartar, seemingly a very harmless thing. Let us see what it is composed of. Our highest power is only six hundred diameters, but it will enable us to see something in this little mass of tartar which will certainly not be a subject of laughter.

"Now you may take a look and see what a neglected mouth contains! We have a mass of animation much resembling the vibriones, which we had under our glasses a few days ago. Our power is too small to discover the different shapings of these parasites, but when one is used high enough to thus distinguish them, they are found of almost every horrible shape—snakes, worms, spears, crosses, hooks, and daggers, intertwined and wriggling with disgusting reality. Dr. Harrimore has estimated that a cubic inch of tartar taken from the teeth will

contain not less than two hundred and fifty million of these animalcules. If this be true—and there is no reason to call it in question-every atom of this substance must contain thousands of these minute creatures. I do not wonder that some of you put your hands over your mouth; but it is needless, they will not jump out; their place of abode is too congenial, and nothing but a thorough cleansing with soap and brush will dislodge them. If you suffer them to remain, they will destroy the gums, corrode the teeth, and taint the breath, and you will pay the painful consequences in aching teeth, which you will soon lose. Take care of your teeth. Nature is bountiful in supplying you with a second set, and sends these scourges to punish those who abuse her munificence.

"Another little matter of the toilet, more especially interesting to the girls. In one of our former lessons we referred to the animalcules found in damp hairbrushes, and now recall the subject as one of no small importance. The Bible tells us that 'if a woman have long hair, it is a glory to her: for her hair is given her for a covering.' A beautiful head of glossy hair is a rich gift, for which its possessor should be thankful, and it is a crime to defile it by neglect or the use of improper applications.

"Conceive of those glossy curling locks filled with

rotifers, vorticella, diatoms, and algæ, crawling and multiplying, and what is worse, with millions of 'Gregaria,' which not only infest the hair, but burrow into the skin. This conception becomes a fact in every case when water is used in dressing the hair, as can be abundantly proved by inspecting the brush employed on the hair through which it has passed. When water is constantly used the hair acquires a strong acid smell, and is then always filled with a fungus growth, which multiplies with astonishing rapidity. The head is then not unlike a mossy stone. Use no water, grease, or other artificial compounds on your hair, except to shampoo the head with clean water and soap once or twice a week, wipe it dry, and then use a dry brush or comb. In this way you will keep the 'glory of woman' bright as a crown, and pure.

"We have been describing the conditions of the natural hair, but what shall we say of the artificial substitutes so lavishly used by the votaries of fashion? Live hair in its process of growth has some power to throw off the impurities which come in contact with it, but dead hair breeds and nourishes them; hence it is always infested to loathsomeness, and nothing short of heat can render it pure. As this element would soon destroy its texture altogether, it can be only partially used, and not sufficiently to thoroughly

cleanse the article, hence it may be settled as an axiom that all false hair is filthy. Nor are the substitutes exempt from this charge. Jute, the principal one, Prof. Haamel tells us, is infested with a parasite having much the appearance of a common wood tick, with crab-shaped arms, which are constantly in motion, by the use of which it penetrates the scalp, producing diseases of the skin, thus causing the natural hair to fall off. Girls, you have been on the seashore, and noticed how the multitudes of 'fiddler crabs' would troop off sideways to their hidingplaces when your presence disturbed them. Just think of the pile of jute on the back of the head of some fashionable lady, and the swarm of tick-like animalcules crawling through it, and how would you like to pin it to the back of your head?"

As the teacher was describing this fashionable breeder of vermin, three or four of the larger girls, who were adorned with these adjuncts of the head, had divested themselves of their chignons, which was noticed by the school, and produced no little merriment. That night there were several little bonfires in which jute formed the material of combustion—an example which it would be well for all to follow who wear it.

"Though our researches," continued Mr. Willard, "into the minute forms of nature have developed

such wonderful things, the results are meagre compared with what lies yet concealed. There is another field of exceeding beauty and interest which we have not even touched, and can now only briefly refer to-the inorganic or mineral kingdom. In this department we find the most valuable metals for use and the precious gems so much prized for their exceeding brilliancy. In themselves they are beautiful objects to look upon. Their perfection of form and sparkling appearance are attractive, but how wonderfully all these attractions are increased when, by a curious process, these gems are made to glow with all the colors of the rainbow, and that too seemingly not at rest, but curiously in motion, revolving like the Chinese wheel! This effect is produced by what is called Polarisation—a process too difficult for you now to understand, but you can have a demonstration of its exceeding splendor, as I have a Polariscope constructed by Mr. Nicol. By this process the different minerals are proved to have the power, like the prism, of analyzing the rays of light, and that each one has favorite colors of its own. When these are so mysteriously put in motion, we have some of the most inconceivable and beautiful combinations. I will adjust the polarizer to one of our instruments, and place a few minerals under it, and give you a glance at this en-

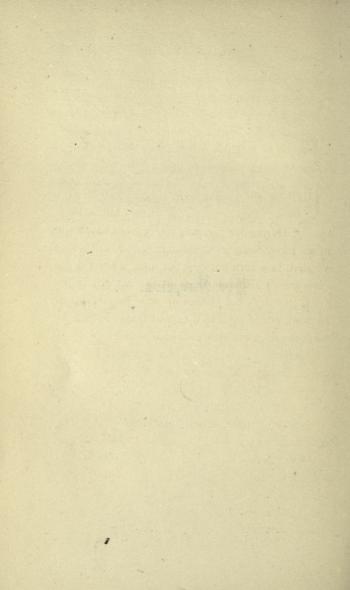
chanted world. Here is a crystal of common granite, one of the earliest minerals found in the earth's crust. To the eye it has no particular attractions, but look at it under this magical transformer, and it is glowing with beautiful colors. And here is another substance which enters largely into the composition of the earth's substance, and is also found in combination with animal structures, when it is productive of many remarkable changes. Here is one made up of green and golden chains and brooches, changing to an intermixture of garnet and topaz. Here is another of prismatic wheels, where the same colors predominate, and still another, where the red take the place of the golden rays. Thus we may go on through an endless scene of dazzling transformations of stars and crosses, crescents and crowns, pearls and diamonds, yet we are dealing with but one of God's precious gifts-light! By its aid all things else are seen, yet itself seldom noticed when thus ministering to our happiness; but lest we should despise this ever-faithful servant, the rainbow spreads over the heavens the evidences of its beauty, and the microscope brings it nearer to our senses, and reveals it modestly hidden in the cloud, and by the process we have just been considering sets it before our wondering eyes arrayed in more glory than anything it reveals.

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"But where shall we stop? Wonders on wonders throng around us everywhere, whether we look up or down, in the rock or in the water, in the plant or in the animal, in life or in death! We have only begun, and can never reach the end, so we may as well stop here and praise the infinite grace which has given some of us the ability, I trust, to see the end of all true knowledge, the beginning and the end of all things: 'Lift up your eyes on high, and behold who hath created these things, that bringeth out their hosts by numbers; he calleth them all by names, by the greatness of his might, for that he is strong in power; not one faileth.'"

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CHAPTER XIX.

THE SURPRISE.

"THIS is our closing exhibition," said Mr. Willard, his voice tremulous with suppressed emotion. "During our pleasant interviews what strange things have come to us through these little tubes! We shall now turn our eyes out upon the world with a new sense. Henceforth to us the air will be full of life, the dry land heaped up with the living and the dead, out of sight to the great mass of mankind, but ever present to our quickened senses. With our new faculty we can see them leaping, crawling, boring, flying, all around and all above us, life everywhere, death everywhere, within and without us, intangible, yet sublimely real!

"In closing these stated interviews it is to me a pleasant inference, from the continued interest which you have manifested, that I have succeeded to a gratifying extent in my purpose to amuse and instruct you, and far above this emotion is the devout thankfulness which I feel that I have had some humble instrumentality in leading some of you to

the fountain of life. It would be impossible for me to express the deep emotions which I yesterday felt as I witnessed your professions of love to the precious Redeemer, and heard your lips give testimony to the fact that my efforts had been thus highly owned of God. Oh that others of my dear pupils may be led in the same gracious way! for 'I have no greater joy than to hear that my children walk in truth.'

"Be assured I shall ever hold in the sweetest remembrance the occasion which has brought us so intimately into communion with the marvelous works of God, and, as an inseparable result, into closer and dearer relations to each other.

"Before closing these delightful and stated interviews permit me once more to try and impress upon you a profound determination to cherish the grand moral lessons which we may deduce from the subject that has so delightfully employed our time. The study of atomic life shows us how minute is God's searching inspection into all the economy of nature, and does he not look as minutely into all the subtle depths of thought and action? It can be truly said, 'He knoweth our thoughts afar off;' he traces all their sources, and notes all their moral shadings; he sees what may escape our closest inspection. We are accustomed to speak of the springs in the moun-

tain-side as the sources whence God fills up the great and wide sea, and in so doing show our ignorance of God's wondrous ways. It is not in the mountain spring nor the glittering drop of morning-dew that God treasures up his watery stores: his fountains are invisible

"I take this glass tumbler and wipe from its outer surface all moisture, then fill it with water. I can place the water within, but God will not use the fountain which I can measure to represent his resources. Like the animalcules, they are hidden in their minuteness, yet everywhere present. Mark how we can detect them. I place in this glass of water a small piece of ice. Now you notice the surface, hitherto clear, so that you could look through the tumbler and contents, begins to grow dim and shuts out our gaze. I draw my finger down the outside of the glass and a stream of water follows it! God's ocean reservoirs are the invisible atoms of moisture diffused throughout the atmosphere, and when he wishes to water the earth and fill up the sea, he 'bringeth the cold out of the North,' and the hidden treasures of the rain start from their hiding-places to go forth with the voice of thunder to do his gracious bidding: 'He causeth the vapors to ascend from the ends of the earth; he maketh lightnings for the rain; he bringeth the wind out of his treasures.' What a wonderful unity in all God's works!

"We have also learned how infinitely far-reaching is his abounding goodness. He organizes the animalcule the fifty-thousandth part of an inch in length, and hides him away from the sight of man. but does not neglect him because of his insignificance and seeming uselessness. He makes provision for all his wants, furnishing materials with which to build a house, and a storehouse from whence he may draw supplies for himself and to nourish his young. Can we suppose that a God so careful of such insignificance will in any way neglect those whom he created in his own image? To assure us of his minute carefulness, he tells us that the 'hairs of your heads are all numbered'-a fact which we do not know and never will find out, but he has booked them all, and not one shall be plucked out but he takes the care of its disposal. Oh what a precious song is the twenty-third Psalm! Who can repeat it without feeling the blessed assurance with which it closes?-'Surely goodness and mercy shall follow me all the days of my life, and I will dwell in the house of the Lord for ever!'

"Too many entertain the idea that God's providence is shown only in the general, and that he is ever on the watch to trap the erring, and hasty and severe to punish. Whereas, whether we learn his goodness from the study of nature or the pages of revelation, the very reverse is true. His care is minute and individual, and his forbearance and longsuffering wonderful. He is not willing to punish, but ever ready to forgive. While he searches out all our little sins, he does not supply only our great wants: while he holds us accountable for a vain thought, he does not heal only a broken bone. No, no! He is minute and particular in blessing, also. He marks carefully the coming danger, and sends his guardian angel to ward off the calamity. His eye beholds the corpuscle of blood bearing the seeds of disease to the citadel of life, and turns it from its fatal pathway to exhale through the pores of the skin, and the waiting winds bear the miasmic seed away, and the plague comes not nigh our dwelling. His eye beholds the devious pathway in which your feet are treading, from which his hand removes the danger and builds a firm foundation for each footstep.

> 'The steps of faith fall on a seeming void, And find a rock beneath.'

"Let us, then, look up from the infinitely small to the Infinitely Great, and in so doing we shall find a Jacob's ladder from the one to the other, on

which not only angels, but every devout heart, can ascend to heaven. The rock that pillows the head or forms the footsteps, the drop of animated water, the minute shell or fossil, if our minds are quickened to spiritual apprehension, will be our 'Ebenezer,' bringing a devout realization of the divine presence, and we shall be enabled exultingly to say, 'Surely the Lord was in this place.' Too often, alas! we fail to recognize his presence or to ascend one round of the ladder toward heaven, where he is seated who created all things by the word of his power. God has placed man at the head of all, to the intent that he might glorify him with devout love and thanksgiving. How ungrateful and groveling must he be who can refrain from giving him the honor due unto his name!

"We must not fail to learn one more lesson to guide us in the delightful work of doing good. Many children think that because they cannot do some great and striking act, such as men perform, therefore they must wait until they grow up to manhood before they try to do anything. But the truth taught us by the study of little things is quite different from this. It teaches us that the many little things make up the great thing. The polyp is not the coral island, but the island is the polyps' work. Thus it is not by one act of kindness, however great

it may be, that one becomes entitled to the blessed appellation of a merciful man. To win this Godlike distinction, there must be a habit of doing good—a habit which will enter into the smallest affairs of life. It is said that 'charity gives away more pence than pounds,' meaning that he who gives away a penny a day until it makes a pound does more good than he who gives it by one act. Each penny may bring a blessing from the poor, while the pound will invoke but one. True kindness is not one act, but the spirit that pervades all actions. Do all the little kindnesses you possibly can, and great ones will be accomplished before you are aware.

'Oh may our sympathizing hearts
That generous pleasure know,
Kindly to share in others' joy,
To weep for others' woe!

'When poor and helpless sons of grief In deep distress are laid, Soft be our hearts their pains to feel, And swift our hands to aid.'

"The sanguinary struggle in the Crimea is a comparatively recent historical event. During its progress, I read the stirring reports of battles and sieges with at least ordinary carefulness, yet how soon they have passed from the memory! Generals of undoubted skill and bravery fought and perished there,

vet of all their names and deeds I can distinctly remember but one, General Cathcart, and I do this by associating his name with a minister who is my personal friend. But the Lord has said, 'If any man serve me, him will my Father honor.' There are two names connected with the Crimean war which will never be forgotten-Florence Nightingale and Hedley Vicars. Amid the dread struggle of arms their deeds were unnoticed, and their names only heard in gentle whispers on the lips of the suffering and dving to whom they ministered and brought the consolation of a Saviour's love. But while the fame of the worldly hero dies away almost as soon as the thunder of the cannon by which his victories were won, the glory of these heroic servants of God is spread wider and wider, and brightens with every increasing circle. It is a most striking illustration of the power of goodness that the long and fearful struggles of four great nations produced no name which will be cherished so long and lovingly as that of a modest Christian woman, who, in the spirit of her Master, 'did what she could.' Wherever history portrays the scenes of that Crimean contest, her deeds will be told 'as a memorial of her.' This will be true also, though perhaps in a less degree, of Captain Vicars, who, amid the temptations and conflicts of the camp and battle, could serve his Master as faithfully as he did his queen. Generals and colonels who perished on the same sanguine field will pass from memory, but the humble subaltern who loved his Bible and his Saviour, and who not only owned him in theory, but imitated him in practice, will live in fragrant remembrance while there is a Christian heart to be stimulated by his saintly example.

"Be assured, my beloved children, that it is 'more blessed to give than to receive.' If you fail to understand and practice this grace, you will live to little purpose, and I shall have failed also in one main intention of all my instructions; but hoping other things of you, I shall cherish the expectation that the world will be the better for your living in it.

"And now, beloved pupils, trusting that I have more than repaid you for the disappointment experienced because of my refusal to allow you the opportunity to attend the departed exhibition, I will dismiss you with a most fervent supplication that God will bless to your present and eternal welfare the instruction which I have tried to impart. To some of you I rejoice to know this blessed consummation has already come, but how many are yet undecided or entirely neglectful! Let me call the attention of such to another fact which we have learned during our investigation—the stupendous results of weak, insignificant agencies when left unimpeded to do

their work. A day's hesitation, a thoughtless word, an unguarded act, may fix the destinies of eternity! Little hindrances, which may now be easily put out of the way, may grow by neglect to insuperable difficulties.

"One bright spring afternoon I was engaged dressing some flowers in my garden. A small cloud arose, and a flake of snow floated on its jeweled wing down to the spot where I was stirring the earth around my plants. What is weaker or more easily put out of the way than a flake of snow? But all night the flakes came down silently and softly, until in the morning they were heaped and heaped into mountains of whiteness. I was to start on a journey that morning, but on the railroad over which I was to travel there were nine most powerful locomotives striving in vain to clear a pathway. My journey was out of the question. My loss was the failure to meet some dear friends, an occasion of much regret, but not of self-condemnation or irreparable injury.

"It may be that some cause as trifling as the little snowflake may now be settling down on the pathway of some of my dear pupils. A brush of determination and it is gone, but neglected, it will multiply with fearful strength and rapidity, and, before you are fully conscious of your danger, place your soul beyond the possibility of hope. Who will run the fearful risk? Whatever of pleasure and information I may have given you during these pleasant reunions, I should feel recreant to my duty did I not urge you, by all the considerations drawn from the value of your souls, the love of our Lord Jesus Christ, and the realities of eternity, to make this subject the first all-absorbing subject; and may the God of all grace bring you all to know Christ here and to share his glory hereafter!

"Should his gracious benediction thus come down upon you, I am sure that my own happiness will be enhanced beyond the power of expression, and I shall count the time spent in these hours of investigation as among the richest of my life. May God bless you, beloved children, and make you as happy and useful as my devoutest wishes would have you, and then beyond all peradventure your lives will be a blessing to the world and your future a glorious rest!"

At the assembling of the school in the afternoon there was noticed under Alf Green's desk an oblong package. It was the beautiful rosewood box, handsomely inlaid with silver, which contained a splendid microscope of fine workmanship and high power, with all the requisites for its manipulation. Each scholar had contributed something toward its purchase, and had so carefully concealed the matter

that Mr. Willard was wholly unconscious of what was coming.

Alf drew the box from its resting-place, and holding it in his hand, approached the desk where the teacher was still standing. It was some moments before the excited boy could sufficiently control himself to discharge the pleasant duty which his fellow-pupils had assigned him. But after some choking and stammering, he said:

"Beloved teacher, I'm doubly favored to-day, being not only an equal sharer in the delightful interviews which are now about to close, but I have been selected by my schoolmates to present to you a slight token of our affection and gratitude for your kind efforts to amuse and instruct us. These hours have not only given us much present gratification. but will. I'm sure, be to most of us sources of lasting profit. We shall go forth impressed with the wisdom and goodness of God as never before, and with a thirst for still farther researches into the strange world to which you have introduced us so kindly. We think, too, that we shall better understand our relations to those around us-to the poorest as well as the most favored, and especially to our gracious Creator. Your instructions have given a value and interest to common and even despised objects that will invest them with a new charm to us.

"To do all this for us has taken much of your time to which we had no just claim, and also must have put you to considerable trouble and expense. You were under no obligation to compensate us for your refusal to allow us to attend the show. Now. had we attended the menagerie as many successive days as we've spent with you, we shouldn't have enjoyed ourselves near as much, nor treasured up as much information. Most of what was there seen was familiar to us, but here we have entered into new scenes, so strange that they almost seem like a dream.

"Now, we children have reckoned up what it would have cost to attend so often the show that has gone, and think that we ought to put into a shape that will be pleasing to you at least a part of that amount. This our parents have approved. We have understood that you had to borrow the instruments used during these pleasant hours, and that you may not have to do it again, in behalf of my fellowpupils, both girls and boys, I beg leave to present to you this microscope, the best that Dr. Newton could select, with the box and all necessary things to make it complete. Valuable as it is, we do not wish you to regard it as at all expressing the strength of our love and gratitude for your deep and continuous interest in our welfare."

While Alf was delivering his well-conned speech, which older heads had helped him to prepare, Mr. Willard stood quite overwhelmed with this wholly unexpected demonstration, until he could restrain himself no longer, and the tears flowed freely. When the box was placed in his hands he was so confused as hardly to know what to do with it, turning it around and around, as if in doubt whether to keep it or not. But when sufficiently collected to respond, he said:

"My beloved pupils, you have got the better of me at last. I did not anticipate so speedy an illustration of your just comprehension of the spirit of my last lesson. It is indeed more blessed to give than to receive, and however valuable this splendid instrument may be, it will bear no comparison in my estimation to the cherished affection of which it is an expression. Wherever my lot may be cast in the future, and whatever other scenes may engage my attention or friendships entwine around my heart, of one thing I am sure—the old brown school-house at Woodlawn, and the noble, loving band of youth who greeted me beneath its roof, will ever be among the brightest and sweetest treasures of memory, and I shall ever bless the occasion which has served to bind our hearts so indissolubly together."

Most warmly did the children respond to these

ardent sentiments of their affectionate teacher, as was evinced by their tearful eyes.

When the school was dismissed they clustered around their teacher, and, with a hearty grasp of the hand, each gave personally a token of the affection which had been more publicly expressed. Then they scattered to their homes to renew the happiness of the day by recounting its pleasures to their gratified parents

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